Coastal Zone Management Plan for the Richmond River Estuary

Volume 2: Estuary Management Study

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FINAL DRAFT

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Synopsis

This Estuary Management Study (Volume 2) provides background information on the estuarine processes and their interaction in the Richmond River Estuary and defines values, management objectives, issues to be addressed and potential management options. The Coastal Zone Management Plan (Volume 1) provides a ten year strategic plan for the implementation of management strategies.

Acknowledgement

Council has prepared this document with financial assistance from the NSW Government through the Office of Environment and Heritage. This document does not necessarily represent the opinions of the NSW Government or the Office of Environment and Heritage.

Cover photo: Sediment laden freshwater plume discharging from the Richmond River Estuary to the Pacific Ocean at Ballina after a moderate rainfall event (Photo: C. Cooksey)

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PROJECT 10-008 – RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND COASTAL ZONE MANAGEMENT PLAN

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EXECUTIVE SUMMARY

Background

The Richmond River estuary is highly valued by the community and is a focal point for local commerce, tourism and recreation. The estuary, with its associated wetlands and waterways, supports a rich biodiversity and a range of important environmental functions and local industry. Despite these recognised values, the system is under pressure from past and existing development, catchment disturbance and hydrological modification, land use management and large-scale vegetation changes. Looking forward, the estuary faces increased pressure from future development within the catchment, increasing population use of the estuary and the impacts of global climate change.

The natural characteristics of the Richmond River catchment and floodplain, such as the presence of potential acid sulfate soils, a large floodplain to catchment ratio and variable flushing characteristics are all elements that interact with and exacerbate the impact of human pressures. Together these factors contribute to the degradation of the waterway and occurrence of undesirable events such as poor water quality episodes and fish kills, particularly following some flood events.

The Richmond River Coastal Zone Management Program

The NSW Government's Estuary Management Program was established with the aim of protecting and restoring the health and functionality of estuaries along the NSW coastline and to implement the State Government's Estuary Management Policy, 1992. The program encourages local stakeholders to responsibly manage their local estuaries through the formation of an Estuary Management Committee and the development of an Estuary/Coastal Zone Management Plan that reflects the needs of the local community and the environment and which identifies issues, possible solutions and actions to implement these solutions.

Coastal councils are now required to prepare a coastal zone management plan (CZMP) in accordance with the guidelines adopted in 2010 under section 55D of the Coastal Protection Act, 1979 (DECCW 2010c). This Draft Estuary Management Study (EMS, Volume 2 of the CZMP) is a culmination of the Data Compilation Study (WBM, 2004) and the Estuary Processes Study (EPS, WBM, 2006; ABER, 2007; ABER, 2008). The Draft EMS brings together the information to identify the estuary management issues and formulate options for management.

A substantial component of the Draft EMS and Draft CZMP were prepared prior to finalisation of the 2010 Guidelines. However, following public exhibition of the Draft CZMP, the documents were amended to ensure consistency with the minimum requirements of the Guidelines.

Councils are required to submit draft CZMPs to the Minister for certification under the Coastal Protection Act, 1979 (refer Figure 1).

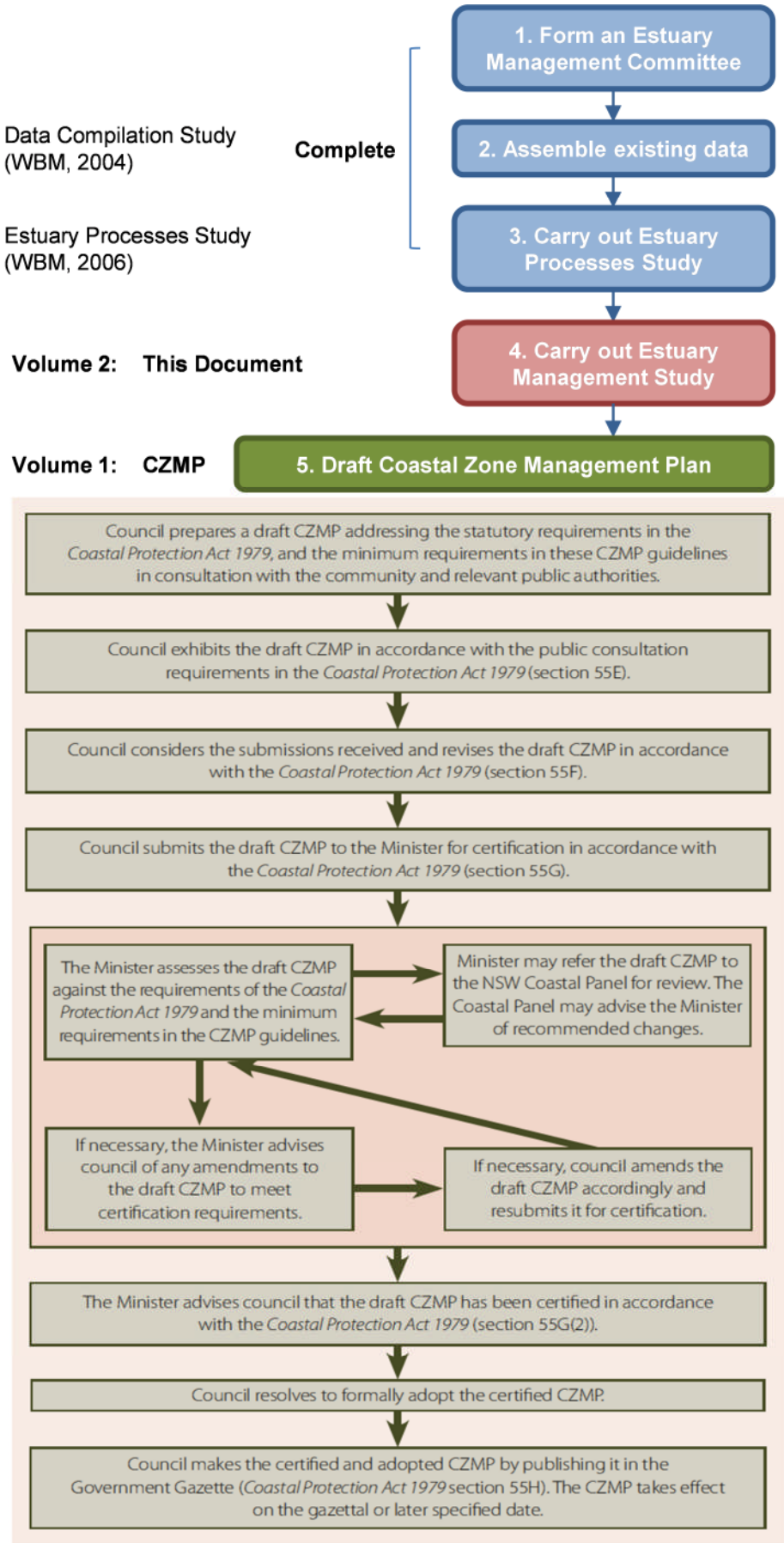


Figure 1 - CZMP preparation and certification process for the Richmond River Estuary

Source: Modified from DECCW, 2010c

Study Area

The Richmond River estuary is located on the far north coast of NSW. The estuary is situated within three local government areas (Ballina Shire, Lismore City and Richmond Valley council areas). It includes the tidal waters of the Richmond River to Casino, Wilsons River to Boatharbour, Bungawalbin and North Creek, and incorporates foreshore and adjacent lands. The study focuses on the immediate catchment of the estuary as this is considered to have the most impact on the health of the estuary and is an important component for future estuary management. The upper catchment is also considered where there is a clear influence on issues to be addressed by this CZMP.

Given the large size of the Richmond River floodplain (approximately 1,000km^2) and three local government jurisdictions, twelve Management Zones were developed dividing the floodplain into smaller units. In defining the zones, the objective was to provide a manageable breakdown of the floodplain area to facilitate implementation of the management actions. The zones align with sub-catchments or with a part of the floodplain that is segregated by geography or infrastructure boundaries such as roads. The zones also break the study area down to a more suitable scale on which to describe the major geographical features of the landscape and to introduce some of the key issues.

Aims of the Estuary Management Study

This Draft EMS brings together the latest scientific knowledge and goals of the community and government agencies to identify estuary values, issues, objectives and develop management options with the aim of improving the health of the estuary and providing for the various uses of the estuary.

Development of the Management Strategies

Management issues for the estuary have been identified from the available background data in the EPS (WBM, 2006; ABER, 2007; ABER 2008) and recent scientific research. The significance and values of the estuary have been derived from the scientific understanding of the estuary and the outcomes of the consultation with stakeholders. These identified values have been used to develop management objectives for the estuary. The management objectives are consistent with the goals and objectives of the NSW Coastal Protection Act, 1979, Coastal Policy, 1997 and Sea Level Rise Policy Statement, 2009.

For each major topic, the identified issues, related objectives and potential management options were identified and prioritised for implementation (refer Figure 2 below).

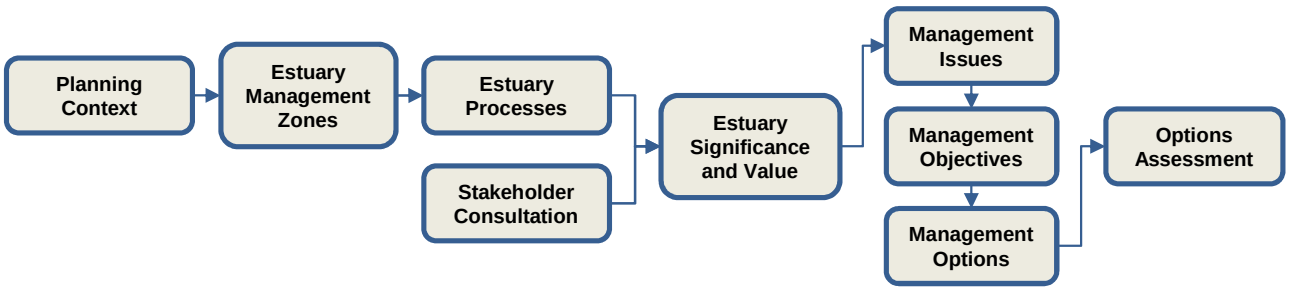


Figure 2 - Development of the Estuary Management Study (Volume 2 of the CZMP)

Management Issues Identified for the Richmond River Estuary

The key issues affecting the Richmond River estuary were identified in the EPS (WBM, 2006; ABER, 2007; ABER, 2008). The EPS documents the scientific understanding of the estuary's physical, chemical and biological processes, their interrelationships and how human activities have impacted upon them. The following discussion summarises the current status of identified issues.

Administration and Governance

The existing estuary management and governance model for the Richmond River estuary needs improvement. The issues raised during development of this study were primarily the lack of a holistic approach to estuary management and poor coordination between the various management entities. It is believed that this presents a significant barrier to successful delivery of on-ground programs and effective estuary management. The issues have come about due to the large number of stakeholders with a range of responsibilities including three local Councils, three County Councils, and various government agencies and organisations. Current legislated responsibilities do not allow any one party to provide an over-arching governance and administration role. Community confusion about the role of the various local and state departments in estuary management was also identified as an issue during the community consultation phase of this study.

Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities.

Climate Change Adaptation

The NSW Government's Sea Level Rise Policy (DECCW, 2009) states that sea level rise is inevitable and establishes planning benchmarks to be adopted in NSW. These benchmarks are an increase above 1990 sea levels of 40 cm by 2050 and 90 cm by 2100, an average increase of 0.8 cm per year.

Sea level rise in the Richmond River estuary is anticipated to result in a broad range of issues including tidal inundation and landward recession of low lying ecosystems, increased salt penetration through the estuary and adjoining wetland systems, increased bank erosion and implications for drainage and flooding in urban and agricultural areas. This issue has broad implications, affecting most of the other estuary issues in some way and therefore needs to be considered as part of all management and planning for the estuary.

Monitoring and Evaluation

Current monitoring does not provide a consistent approach over the catchment. It is generally carried out by a range of agencies and organisations for various reasons and over varying timescales. This means that there is currently no way to monitor the on-going health of the estuary over time or to compare relative sources of water quality degradation across the catchment. These are considered to be fundamental requirements to implement effective and on-going estuary management. Additionally, there is no integrated environmental monitoring and reporting system in place at a scale that is meaningful to determine the effectiveness of management and investment in programs and projects that affect the estuary.

Poor Water Quality Episodes and Fish Kill Events

The Richmond River Estuary has a history of poor water quality episodes, particularly following flood events which are periodically associated with fish kills. There is now recognition of the significant detrimental impact of historic broad-scale land clearing and floodplain drainage and regulation on floodplain wetlands, acid sulfate soils (ASS) management and water quality affecting the overall health of the estuary. While fish kills are a periodically occurring natural phenomenon, research has indicated

that their frequency and severity are greatly exacerbated by catchment and floodplain modification. Further information on specific issues is provided below.

Floodplain Vegetation Clearing and Modification

From early colonisation, European land clearing on the floodplain has replaced flood adapted native trees and shrubs with exotic grasses and crops which quickly die and decompose in summer when flooded. This was found to be a major factor in fish kill events in the Richmond River in the EPS (WBM, 2006) and recent studies have offered greater insight into the nature and extent of blackwater events. Prolonged inundation of the floodplain during and immediately following flooding can cause the decay of the underlying vegetation and rapid decomposition of accumulated organic matter (Eyre *et al*., 2006). The decomposition process strips oxygen from the overlying water, creating 'blackwater'. The mass drainage of this ponded blackwater via the drainage network and tributaries as floodwaters recede can cause hypoxic (very low dissolved oxygen) conditions along large stretches of the estuary (Wong *et al*., 2010). Low dissolved oxygen levels in water causes stress to fish and other aquatic organisms and in extreme cases can result in widespread fish kills such as those observed in the Richmond River in 2001 and 2008.

Floodplain Drainage Infrastructure

The Richmond River floodplain has been extensively modified by a complex network of constructed drains, modified canals, artificial levee banks and floodgates. Installation of floodplain drainage channels began in 1888 and accelerated in the early 1900s for the purpose of draining wetlands for agriculture and for flood mitigation. Floodgates were installed to prevent back-flooding of drains, creeks and tributaries and subsequently the inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides. The impacts of historical and on-going drainage works are now known to have significant environmental impacts on the estuary. These include the exposure and oxidation of ASS, formation of monosulfidic black ooze (MBO) (discussed below), drainage providing a conduit to more effectively convey pollutants to the estuary and disruption of tidal flushing regimes affecting water quality and ecological processes.

Addressing the environmental impacts of floodplain drainage infrastructure whilst maintaining adequate protection against flooding is a key challenge for managing the on-going health of the estuary.

Acid Sulfate Soils (ASS) and Monosulfidic Black Ooze (MBO)

ASS is the common name given to naturally occurring sediments and soils containing iron sulfides. The exposure of these soils to oxygen by drainage or excavation leads to the generation of sulfuric acid often also releasing toxic quantities of iron, aluminum and heavy metals (DERM, 2009). Approximately 68,000 ha of the Richmond River floodplain is classified as having some level of ASS risk. Disturbance of these areas by historical and on-going drainage and agricultural practices has resulted in the oxidation of ASS resulting in chronic and acute discharges of acid and associated pollutants to adjacent waterways (ABER, 2007).

Five priority areas for the management of ASS in the study area were identified and mapped by Tulau in 1999, during a state-wide study of ASS. These are Tuckean Swamp, Rocky Mouth Creek, Sandy Creek – Bungawalbin Creek, Maguires Creek - Emigrant Creek, and Newrybar-North Creek.

Monosulfidic black ooze (MBO) is created by rotting organic matter in ASS environments and typically occurs on drain bottoms and sides. When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways (Bush et al., 2003). MBOs are known to occur in the Richmond River estuary and have been identified as a factor

in fish kills (ABER, 2007). The Tuckean has one of the highest recorded concentrations of MBOs in the world (Bush *et al*., 2004).

Diffuse Pollutant Loadings from Agricultural Land

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Agricultural land use and some management practices are also identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in the estuary including the contribution of significant sediment, chemical and nutrient loads to the estuary during runoff (rain) events (WBM, 2006). Agricultural fertilisers are reported as a major source of nutrients. Transportation of nutrients to waterways during rainfall events dominate the annual nutrient budget for the estuary (ABER, 2007). Grazing is a dominant land use in the Richmond River catchment and unrestricted stock access to waterways creates issues of bank instability and erosion through trampling, damage to riparian vegetation and direct input of nutrients and contaminants from direct contact. Contaminant inputs and increased turbidity have flow-on effects to estuarine ecosystems and productivity in the immediate vicinity and downstream in the estuary (WBM, 2006).

Addressing the impacts of agricultural land use on the estuary, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the estuary. Approximately 75% of the Richmond River estuary study area considered in the EPS (WBM, 2006) is zoned for various forms of agricultural use. Management of these lands has a large bearing on future outcomes for estuarine values.

Poor Condition of the Riparian Zone

The riparian zone (the interface between land and waterways) bordering the Richmond River estuary and tributaries is generally devoid of vegetation for much of the area. Where riparian vegetation is present it is generally degraded, with only a few examples of intact riparian vegetation in good condition.

The issues associated with the poor condition or lack of vegetation within the riparian zone are associated with the loss of the functions and values of this important zone. Riparian zone functions include fisheries habitat, terrestrial habitat, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity. The absence of many of these functions is apparent throughout the majority of the study area.

Vegetation Management

With the exception of the Bungawalbin Creek sub-catchment and the Border Ranges, the majority of the Richmond River catchment has been extensively cleared of native vegetation. The effects of vegetation clearing include:

- Loss of vegetation and associated fauna species resulting in reduced biodiversity values of the Richmond River and its catchment;
- Fragmentation of habitats where fauna rely on vegetated “movement” corridors to move between remaining vegetation remnants. In many places these corridors do not exist;
- Increased sediment and nutrient loads to the estuary; and
- Changes in morphological (erosion, accretion) processes within the estuary (WBM, 2006).

Any further clearing will further exacerbate these issues and therefore remaining vegetation needs to be protected and enhanced wherever possible.

Outbreaks of aquatic weeds are known to occur in several locations within the study area. These weeds can reduce the ecosystem values of open water for birds and fish. Aquatic weeds can cause diurnal fluctuations of dissolved oxygen and provide a source of organic matter for the production of MBOs, which when mobilised by flood flows can completely deoxygenate the water column.

Waterway Usage

The Richmond River estuary is highly valued for various forms of recreational use, and these pursuits constitute the dominant use of the estuary. Commercial boats also utilise the estuary for fishing, oystering and tourism activities which are also of high significance in the region. The key issues identified for management include:

- Current boating facilities are not adequate to meet current (at peak usage) and projected future demand;
- Concern about cooperative use of the waterway between various forms of recreational and commercial users; and
- The protection of the ecological values of the estuary from recreational activities such as propeller and anchor damage to seagrass beds in Mobbs Bay.

The community perceptions around the need for dredging in the lower estuary and concern about impacts on estuarine ecosystems are also issues that continue to be raised within the community.

Wastewater and Urban Inputs

The relative impact of sewerage systems (including STPs and overflow structures) and urban stormwater outlets on estuary water quality varies greatly and is dependent on the volume and quality of flows from these sources compared to loading from diffuse sources in the catchment. In general the EPS (WBM, 2006) reported that during significant rainfall events, the impact of nutrient loads and pollutants from urban runoff and sewerage systems was negligible in comparison to the impact of diffuse loads. Pollutant loads from urban inputs become relatively more important to water quality during the dry season when catchment inputs are low.

The EPS (WBM, 2006) identifies sewerage system inputs during these dry times as a potential risk to water quality although a comprehensive assessment of risk across the study area has not been conducted to date. Stormwater from urban areas has also been identified as a source of pollutants to receiving water bodies including litter, nutrients, sediment, oxygen-depleting substances and hydrocarbons.

STPs are licensed by the NSW Office of Environment and Heritage. Councils monitor water quality discharged to the environment to ensure compliance with licence conditions. Upgrades to STPs occur on an as needs basis to cater for increased population growth, meet environmental standards and replace aging infrastructure.

Rural areas that are not serviced by a reticulated sewage system rely on on-site sewage management systems (OSSMs) such as traditional septic tanks or other treatment systems. Past investigations have indicated that many systems are failing to meet appropriate standards and are potential contributors of contaminants to the estuary. Many OSSMs in the catchment are not registered and condition and impact of systems on water quality in the catchment is unknown. The Councils undertake on-site sewage and wastewater management programs including specification of design requirements and audit and inspection of on-site systems. Inspections are on-going.

All councils within the study area are actively involved in the management of urban stormwater through a variety of projects, programs and policies including Stormwater Management Plans and Development Control Plans.

Cultural Heritage

The Richmond River estuary has high spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuary and their recognition and protection are important to the local community. All levels of Government maintain registers of important sites, which are then afforded varying levels of protection under current legislation. During the community consultation phase of this study, the issue was raised that there were a number of sites of Aboriginal cultural heritage significance in the Richmond area that were currently not registered with relevant authorities and therefore there was concern about the on-going protection of sites.

Fisheries and Aquaculture Management

There is concern that the findings and strategies documented in the General Fisheries Environmental Impact Statement (EIS, NSW Fisheries, 2003) are not well understood within the community and that commercial fishers are being unfairly blamed for fish decline in the estuary.

Despite this, there is increasing recognition in both the recreational and commercial fishing sectors that their respective activities are highly regulated and that factors such as the major fish kills in 2001 and 2008, as well as the cumulative effects of habitat degradation, fish migration barriers and declining water quality are all contributing to reduced fish stocks. The 2008 fish kill and ensuing temporary fishing closure polarised community views on who was to blame and what was to be done to avoid repeat occurrences.

There are a range of issues affecting the oyster aquaculture industry in the Richmond River estuary such as QX disease, water quality issues (e.g. periodically high levels of faecal coliforms in North Creek has resulted in harvest closures), vandalism of oyster racks and theft of oysters and the presence of pesticide residues is an ongoing concern for the industry.

Another important issue raised during community consultation phases was the importance of acknowledging and communicating traditional Aboriginal fishing rights and practices in accordance with Native Title.

Estuary Values

The main aim of the estuary management planning process is to increase resilience within the estuary and to protect and enhance the key values.

Economic Values

- The Richmond River catchment supports a wide range of land uses (particularly agriculture) which are important contributors to the local and regional economy.
- Commercial fishing and oyster aquaculture contribute to the local and regional economy.
- The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits.
- The freshwater sections of the estuary are a valuable source of water for agriculture and also provide potable town water supply from the tidal pool upstream of Lismore.

Social Values

- The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities.
- A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community.
- The estuary and foreshore areas are highly valued by the community and visitors for recreational activities.
- Scenic amenity is valued highly by the local community and visitors.
- The estuary provides opportunities for both formal and informal education.

Ecological Values

- The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species.
- The estuary supports a number of rare and threatened communities.
- Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function.
- The Richmond River estuary is recognised as one of the two most important locations for shorebird habitat in Northern NSW (DECCW, 2010b). The Clarence estuary is the other important site.
- The riparian zone provides a number of important ecological functions.
- Good water quality is highly valued and considered a general indicator of estuary health by the community.

Management Objectives

Based on the established values of the estuary and the issues summarised above, management objectives for the estuary were developed. The objectives set specific aims for future management of the estuary giving consideration to the values and key issues.

Table 1: Richmond River Estuary Management Objectives

No.	Objective
O1	To encourage economically viable and environmentally sustainable land use practices in the catchment
O2	To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP
O3	To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring
O4	To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement
O5	To reduce pollutant loads to the estuary
O6	To protect and enhance the riparian zone
O7	To minimise the frequency and severity of environmental events such as fish kills

No.	Objective
O8	To optimise flood mitigation works and flow control structures to improve estuarine water quality
O9	To minimise constraints to estuary adaptation to climate change
O10	To protect and enhance the biodiversity values of the estuary
O11	To provide for increased use of the estuary whilst minimising environmental impact and conflict between users
O12	To protect the cultural heritage values of the estuary
O13	To protect and enhance visual amenity/ aesthetic appeal of the estuary
O14	To enhance sustainable commercial return from industries relying on the estuary and the floodplain
O15	To minimise risk to the health and safety of users of the estuary

Potential Management Options

A suite of options available for the sustainable management of the estuary has been compiled and developed to a point where the options can be compared and prioritised. The options have been formulated to address the identified issues and achieve the management objectives and are made up of both short-term and long-term components.

The evaluation of potential management options is critical to the development of the management strategies. This has been undertaken as follows:

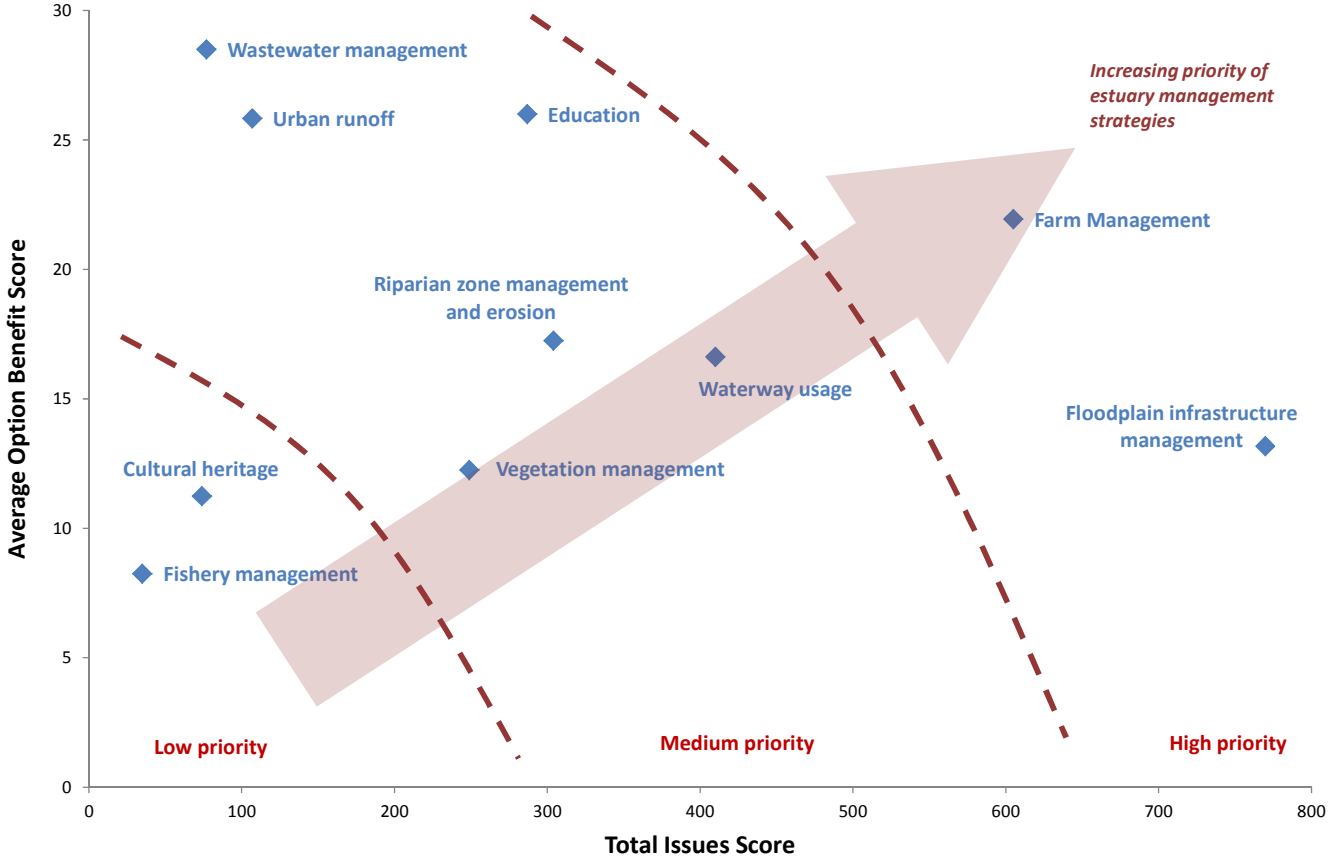
- All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan;
- The individual options were assessed to determine the effectiveness in addressing the priority issues (“Issues Score”);
- The individual management options were assigned an “Option Benefit Score”; and
- The Average Option Benefit Scores (average of the Option Benefit Scores) for each category of option were visually compared with the associated issue priority.

The options considered in this study have been identified for a range of purposes e.g. studies that are required to further refine or prioritise management actions, options that are complementary i.e. they achieve similar outcomes but are applicable to different geographical areas and/or issues, and options that are mutually exclusive in that only one of the options is appropriate. Because of this, the assessment of individual options does not provide a full representation of the required management effort. To address this, issues and options were grouped into categories to enable development and comparison of management strategies.

Figure 3 compares the Average Option Benefit Scores and the Total Issues Scores for each category of issue (Strategies). The Strategies have been assigned a low, medium or high priority based on their capacity to address the identified issues and their overall benefit. Based on the priorities displayed here, the management strategies will be developed as part of the Draft CZMP.

Administration and Governance, Climate Change Adaptation and Monitoring and Evaluation are considered to be fundamental management strategies that influence all options of the management plan. For this reason they have not been prioritised in the same way as the other strategies and do not appear in this chart. The strategies (in priority order) and their component options are shown in Table 2

The classification of strategies as low priority for management is not a reflection of the level of importance of these factors, but rather an indication of the capacity of the actions contained in these strategies to achieve the defined objectives in terms of overall estuary health.



*Note that strategies considered to be fundamental management considerations were not prioritised i.e. Administration and Governance, Climate Change Adaptation and Monitoring and Evaluation.

Figure 3 - Relative Priority of Management Strategies

Table 2: Prioritised Management Strategies and Options

Fundamental Management Strategies	
Administration and Governance	
1	Review estuary governance and administration
Climate Change Adaptation	
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management
Monitoring and Evaluation	
2	EcoHealth monitoring program (comprehensive, catchment-wide monitoring program)
3	Develop catchment/water quality modelling tool to support decision making

HIGH PRIORITY	
Floodplain Management	
4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage
5	Identify and prioritise levees for redesign and/or remodelling
6	Review floodgate management protocols
7	Cost benefit analysis of backswamp farming activities
8	Scientific trials to investigate strategies for retention of water on backswamp areas
9	Changes in pasture management including changes to inundation tolerant pasture species
10	Retirement/buy back backswamp areas and return to wetlands
11	Work with backswamp property owners to identify alternative management strategies
21	Review water sharing plans regarding groundwater extraction and acid sulfate soil (ASS) effects
Farm Management	
12	Farm management planning for priority properties
13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines
14	Identify high impact farming activities and investigate alternatives

MEDIUM PRIORITY	
Education	
37	Estuary-wide community education and consultation program
Waterway Usage	
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary
Riparian Zone Management and Erosion	
22	Riparian buffer zone identification (planning)
23	Identify priority riparian areas and rehabilitate

Wastewater Management	
19	Support the continuing upgrade / augmentation of Sewage Treatment Plants (STPs) where required
20	Wastewater Reuse
40	Support the on-going on-site sewerage management inspections and improvements
Urban Runoff	
16	Further promote Council's stormwater education programs
17	Support and promote existing planning mechanisms for Water Sensitive Urban Design (WSUD) for new developments
18	Continue Council's program for retrofit of GPTs and other stormwater improvement devices
Vegetation Management	
24	Continue aquatic weed management and support improved technology for better environmental outcomes
25	Retain, rehabilitate and conserve existing native floodplain vegetation

LOW PRIORITY	
Cultural Heritage	
35	Identification and registration of cultural sites available to council planners
36	Develop Cultural Site Management Plans for sites in and around the estuary where appropriate
Fishery Management	
29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public as well as within and across government agencies.
30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures
31	Further research into sources of water quality issues in North Creek

Development of the Coastal Zone Management Plan

Based on the options identified as part of this Draft EMS, a prioritised schedule for implementing the management strategies has been developed and presented in the Draft CZMP (Volume 1). The implementation of the plan will be supported by a process for reviewing the effectiveness of the plan and adapting it as required. This aspect of the project is essential for ensuring that the estuary management options identified become a reality and that the estuary is better managed into the future.

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1. INTRODUCTION

1.1 Purpose of this Estuary Management Study

The purpose of this Estuary Management Study (EMS) is to investigate the current uses and health status of the Richmond River Estuary and to define management objectives and options for future management of the estuary. The Draft EMS achieves this by drawing upon previously completed studies into the estuarine processes and the values associated with the estuary and identifies how the values are impacted by those processes. The Draft EMS defines management objectives for the long-term strategic management of the Richmond River Estuary and investigates management options to address the current and future threats to its social, environmental and economic values.

Volume 1, the Draft Coastal Zone Management Plan (CZMP) for the Richmond River Estuary (CZMP) documents the recommended actions that are required to achieve the objectives for management of the estuary.

1.2 The Study Area

The Richmond River estuary is located on the far north coast of NSW. The estuary is situated within three local government areas (Ballina Shire, Lismore City and Richmond Valley Council areas) as shown on Figure 4. An additional three councils (Clarence Valley, Kyogle and Byron Shire) have jurisdiction in the upper catchment.

The region experiences a mild subtropical coastal climate with moderate maximum and mild minimum temperatures and high intensity rainfall. The ocean controls the climate of the coastal towns, with more inland centres such as Lismore and Casino experiencing higher maximum and lower minimum temperatures. The majority of rain falls in the summer and autumn months (WBM, 2006).

The study area includes the tidal waterways, foreshore and adjacent lands of the Richmond River estuary, including the entrance and lower reaches of the major tributaries. The study focuses on the immediate catchment of the estuary as this is considered to have the most impact on the health of the estuary and will form the focus for future (estuary) management. The upper catchment is also considered where it affects the issues to be addressed by the study, such as urban, agricultural and forestry runoff, which contribute to increased surface flows and input of sediment and nutrients.

Given the large size of the study area (floodplain >1,000km^2) and the three local government jurisdictions, twelve management zones were developed. The management zones are discussed in Section 3.

Figure 4 - The Richmond River Catchment and Estuary Management Study Area

1.3 Structure of this Report

The sections of this Report describe the steps in the development of the potential management options for the Richmond River Estuary. The process followed is summarised in Figure 5.

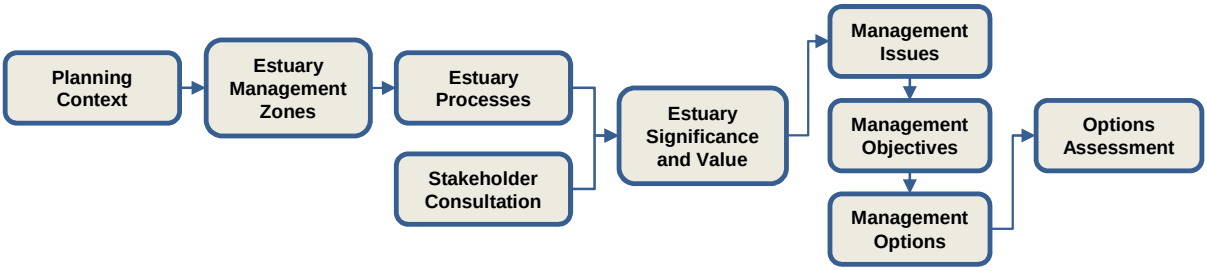


Figure 5 – Development of the Estuary Management Study

Section 1 - Introduction: Introduces the purpose of the document and the study area.

Section 2 - Planning Context: discusses the planning framework, administration and governance that applies to the management of the Richmond River estuary

Section 3 - Estuary Management Zones: Describes the major features and values of the estuary management zones and introduces the issues in each zone.

Section 4 - Estuary Processes: Provides an update of recent technical information related to the management of the Richmond River Estuary, since the completion of the Estuary Processes Study.

Section 5 - Stakeholder Consultation: Summarises the consultation activities undertaken as part of the Estuary Management Planning Process.

Section 6 - Estuary Significance and Values: Discusses the significance and values of the estuary derived from the scientific understanding and the outcomes of the stakeholder consultation.

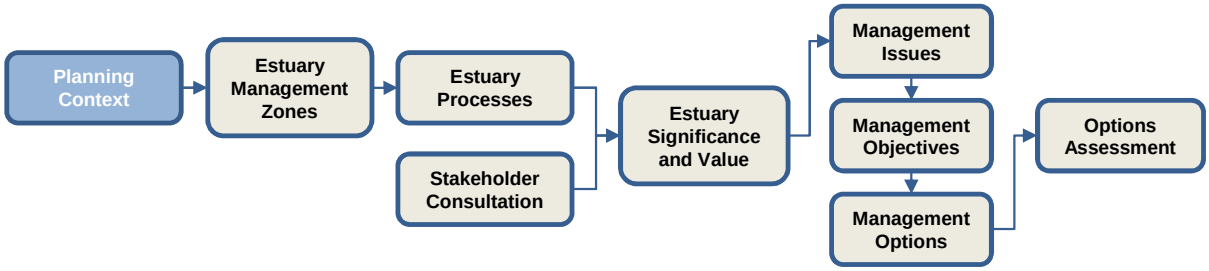
Section 7 - Estuary Management Issues, Objectives and Options: Outlines the current status of identified issues in the estuary. Based on the established values of the estuary and the issues, management objectives and options were also developed to protect the identified values.

Section 8 - Estuary Management Options Assessment: Options are compared on a triple bottom line basis.

Section 9 - Preparation of the Coastal Zone Management Plan: describes the next steps in the CZMP process.

The Appendices provide detailed information on certain aspects of the EMS.

2. PLANNING CONTEXT



This Section discusses the planning framework, administration and governance that apply to the management of the Richmond River estuary. The development of management options will be consistent with the existing policies and strategic plans.

Detailed information on the planning framework is provided in Appendix 1.

2.1 The Richmond River Coastal Zone Management Program

The NSW Government's Estuary Management Program was established in 1992 with the aim of protecting and restoring the health and functionality of estuaries along the NSW coastline and to implement the State Government's Estuary Management Policy, 1992. Coastal councils are now required to prepare a Coastal Zone Management Plan (CZMP) in accordance with the guidelines adopted in 2010 under section 55D of the Coastal Protection Act, 1979 (DECCW 2010c). The Guidelines replace the Estuary Management Manual (NSW Government, 1992).

This Draft Estuary Management Study (EMS, Volume 2 of the Draft CZMP) is a culmination of the Data Compilation Study (WBM, 2004) and the Estuary Processes Study (WBM, 2006, ABER, 2007; ABER, 2008). The Draft EMS brings together the information to identify the estuary management issues and formulate options for management. A substantial component of the Draft EMS and Draft CZMP were prepared prior to finalisation of the 2010 Guidelines. However, following public exhibition of the Draft CZMP, the documents were amended to ensure consistency with the minimum requirements of the Guidelines. Councils are required to submit draft CZMPs to the Minister for certification under the Coastal Protection Act, 1979 (refer Figure 6).

This document has been prepared with financial assistance from the NSW Government through the Office of Environment and Heritage.

2.1.1 Management Framework

The Draft CZMP supports the goals and objectives of the NSW Coastal Policy 1997 and the NSW Sea Level Rise Policy Statement, 2009 and assists in implementing integrated coastal zone management. The Draft CZMP was prepared in accordance with Part 4A of the Coastal Protection Act, 1979 and CZMP guidelines (DECCW, 2010c).

NSW Coastal Policy, 1997

The NSW Coastal Policy, 1997 was introduced with the aim of protecting and conserving coastal environments, including estuarine environments, for future generations. The Policy responds to the fundamental challenge to provide for population growth and economic development without placing the natural, cultural, spiritual and heritage values of the coastal environment at risk. The Coastal Policy represents an attempt by Government to better co-ordinate the management of the coast by identifying, in a single document, the State's various management policies, programs and standards as they apply to a defined coastal zone. The overriding vision of the 1997 Coastal Policy is the ecologically sustainability of the NSW Coast. Nine goals have been adopted which represent a commitment to:

- Protecting, rehabilitating and improving the natural environment of the coastal zone;
- Recognising and accommodating the natural processes of the coastal zone;
- Protecting and enhancing the aesthetic qualities of the coastal zone;
- Protecting and conserving the cultural heritage of the coastal zone;
- Providing for ecologically sustainable development and use of resources;
- Providing for ecologically sustainable human settlement in the coastal zone;
- Providing for appropriate public access and use;
- Providing information to enable effective management of the coastal zone; and
- Providing for integrated planning and management of the coastal zone.

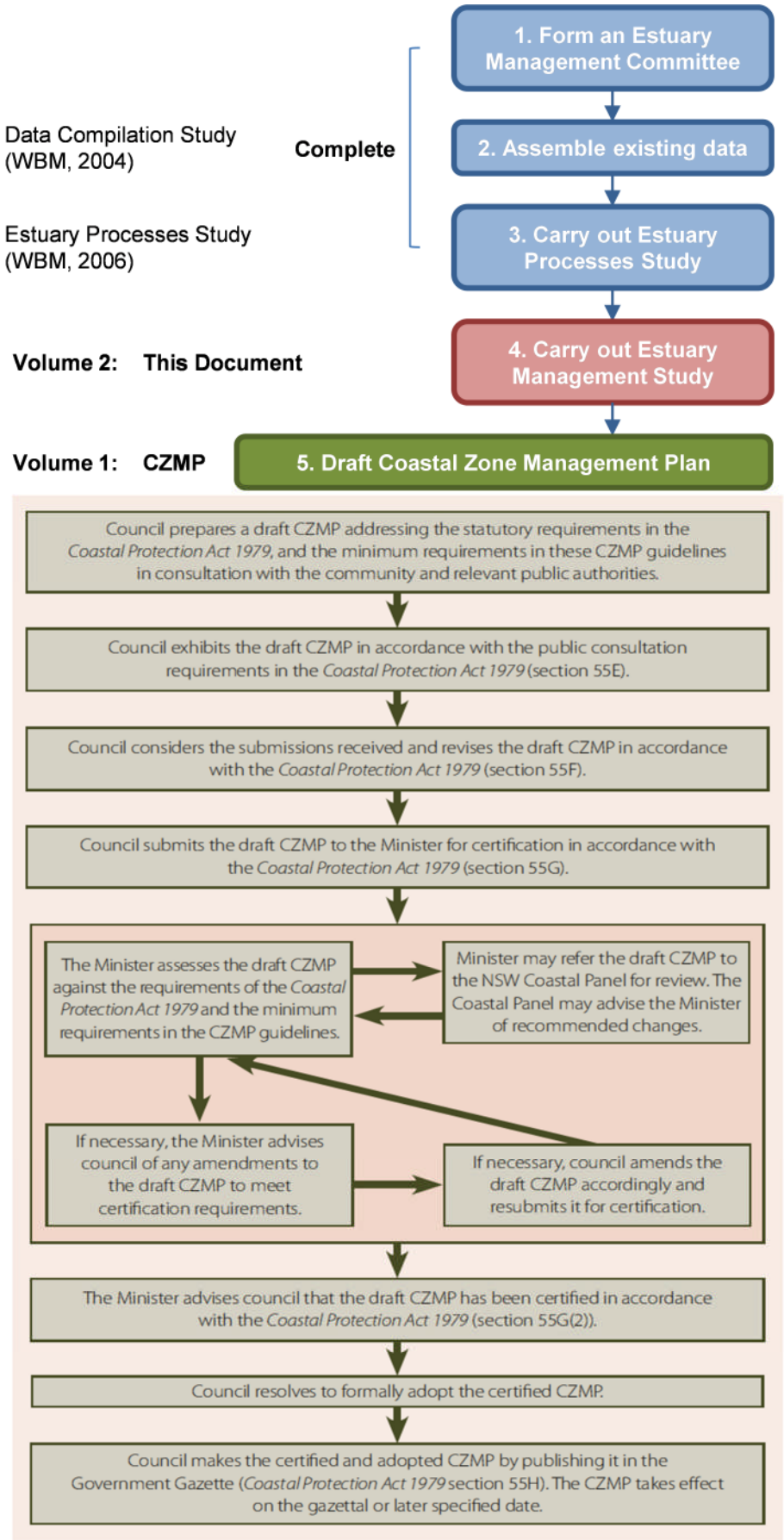


Figure 6 - CZMP preparation and certification process for the Richmond River Estuary

Source: Modified from DECCW, 2010c

Coastal Protection Act, 1979

The Coastal Protection Act, 1979 makes provisions relating to the use and occupation of the coastal region in order to preserve and protect these areas whilst encouraging sustainable use of the areas. The Act also facilitates the carrying out of certain coastal protection works. The objectives of the Act are to provide for the protection of the coastal environment of the State for the benefit of both present and future generations and, in particular:

(a) to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and

(b) to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and

(c) to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including:

  (i) benefits to the environment, and

  (ii) benefits to urban communities, fisheries, industry and recreation, and

  (iii) benefits to culture and heritage, and

  (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, and

(d) to promote public pedestrian access to the coastal region and recognise the public's right to access, and

(e) to provide for the acquisition of land in the coastal region to promote the protection, enhancement, maintenance and restoration of the environment of the coastal region, and

(f) to recognise the role of the community, as a partner with government, in resolving issues relating to the protection of the coastal environment,

(g) to ensure co-ordination of the policies and activities of the Government and public authorities relating to the coastal region and to facilitate the proper integration of their management activities,

(h) to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise, and

(i) to promote beach amenity.

2.2 Administration and Governance

The management of the Richmond River Estuary is undertaken by various local and state government bodies.

2.2.1 Local Government

Councils have a central role in the management of estuaries. There are three local general purpose councils with jurisdiction in the study area: Lismore City Council (LCC), Richmond Valley Council (RVC) and Ballina Shire Council (BSC). There are also three council appointed and funded entities: Richmond River County Council (RRCC), Far North Coast Weeds (FNCW) and Rous Water, which have certain responsibilities legally delegated to them by the general purpose Councils.

General Purpose Councils

The local general purpose councils are responsible for land use allocation and development in the immediate area and surrounding the estuary. The councils also have significant planning and development powers as consent authorities under the Environmental Planning and Assessment Act,

1979. Together with other government agencies and catchment management authorities, councils act as an interface between the community and state authorities.

The Local Government and Shires Associations of NSW website provides a useful description of local government responsibilities with regard to natural resource management. This is provided below:

As the sphere of government closest to the community, local government is responsible for good governance and the care and protection of local communities within a framework of sustainable development.

As managers of public land and land use planners, local government is responsible for policy development and implementation of land use planning as well as regulating a wide range of activities that may impact upon natural resource management. Local government also has a key role to play in translating the policies of Commonwealth and state governments into on-ground projects.

Local Government has a range of functions, powers and responsibilities at its disposal to influence natural resource management - on both private and public land. These include:

- Strategic planning through land use zoning and statutory controls on all freehold land and locally managed public open space;
- Development control of activities and works on land as specified by Council's LEP;
- Enforcement powers for development consent conditions, waste management and unauthorised land uses (e.g. land clearing, drainage, and filling);
- Administrative responsibility for state agency coordination through integrated planning, licensing and development concurrence;
- Stormwater management and control; sewerage and drainage works, and flood control;
- Pest, plant and animal risk control measures;
- Influence over land clearance patterns through incentive programs (planning amendments, rate differentials, levies, rural fire management and developer contributions);
- Management of local open space to restore remnant vegetation and recreate habitat; and
- Primary advocate for and coordinator of local community groups and interests.

County Councils

RRCC was constituted by proclamation on 25 November 1959 and has been delegated with the responsibility for flood mitigation activities for Ballina, Lismore and Richmond Valley Councils. RRCC's proclamation was amended most recently on 5 September 2008, when natural resource management was formally incorporated as an RRCC function where issues arise from RRCC's flood mitigation activities (refer to amendment published in NSW Government Gazette No. 110, 2008). RRCC receives Council contributions to fund delegated responsibilities and for maintenance of council assets. State government also provides contributions for maintenance of floodgates drains and levees.

RRCC is responsible for exercising all the powers and duties under the Local Government Act 1993 in relation to the prevention or mitigation of menace to the safety of life or property from floods and natural resource management issues arising therefrom. This involves water quality monitoring, research, environmental education, works to improve discharge from community flood mitigation infrastructure, drain modification, wetland and creek restoration. RRCC also has a coordinating role in floodplain management, working with constituent Councils, State agencies, and floodplain industries to develop long term effective natural resource management strategies for the Richmond River floodplain and estuary (RRCC, 2009). However, the RRCC delegated responsibilities are limited to impacts associated with flood mitigation activities which are primarily restricted to floodplain drainage

infrastructure and maintenance, and therefore do not cover all of the estuary management issues (such as waterway usage, riparian zone management, farm management, fisheries and aquaculture, wastewater management, urban runoff and heritage).

FNCW is the local control authority responsible for administering the Noxious Weeds Act, 1993 in the Northern Rivers region of NSW. Responsibilities include:

- Controlling noxious weeds on public land including roadside weed management and aquatic noxious weeds on rivers and public lagoons;
- Conducting inspections of private property for presence of noxious weeds;
- Enforcement of control of noxious weeds through requests and fines as necessary; and
- Provide advice on weed management issues.

Rous Water is the regional water supply authority providing potable water in bulk to the Council areas of Lismore (excluding Nimbin), Ballina (excluding Wardell), Byron (excluding Mullumbimby) and Richmond Valley (excluding land to the west of Coraki). Catchment management activities are carried out by Rous Water to protect its drinking water sources and to protect and restore ecological systems and improve waterway health and water quality.

2.2.2 State Agencies

There are a number of State agencies who have various regulatory and strategic roles related to the estuary. These include:

- Office of Environment and Heritage (OEH), within the Department of Premier and Cabinet, including:
    - the National Parks and Wildlife Service (NPWS); and
    - in regulatory matters for environment protection, OEH acts under the powers of the Environment Protection and Regulatory Group (EPRG).
- Department of Primary Industries (within the Department of Trade and Investment, Regional Infrastructure and Services) including:
    - The NSW Office of Water - responsible for the water management functions (including legal, policy and regulation);
    - Primary Industries - Agriculture;
    - Primary Industries - Fisheries;
    - Marine Parks Authority;
    - Catchment Management Authorities (refer Section 2.2.3); and
    - Crown Lands division – responsible for ownership and management of Crown Land which in most cases is the bed and banks of estuaries below mean high water level and other land parcels including foreshore reserves, road reserves.
- Department of Planning – the state authority on planning and environmental assessment matters; and
- NSW Maritime – responsible for marine safety, regulation of commercial and recreational boating and oversight of port operations.

2.2.3 Catchment Management Authority

The 2006 Northern Rivers Catchment Action Plan (CAP) has been developed by the Northern Rivers Catchment Management Authority (NRCMA) under the Catchment Management Authorities Act 2003 (NRCMA, 2006). The Plan sets a 10-year investment strategy for targeted investment for the region which extends over most of the NSW North Coast, from the Camden Haven River in the south to the Queensland border in the north and extending west to the Northern Tablelands.

The CAP draws together targets outlined in three previous Catchment Blueprints that have been reviewed and evaluated through a facilitated process of stakeholder engagement. Targets aim to improve the natural assets such as water, coastal landscapes and estuaries, the marine environment, soil, cultural heritage and biodiversity. The CAP also promotes the value of communities in the catchment, and aims to capture the communities' priorities and aspirations for the protection and enhancement of natural resources in the region.

2.2.4 The Richmond River Estuary Management Committee

The role of an Estuary Management Committee is to provide ongoing feedback during the various steps of the CZMP preparation process. The Richmond River Estuary Management Committee comprises representatives from a wide range of stakeholders:

- BSC;
- LCC;
- RVC;
- OEH – EPRG;
- OEH - NPWS;
- DPI – Agriculture;
- DPI – Fisheries;
- RRCC;
- Richmond River Cane Growers Association;
- NSW Sugar Cooperative;
- NSW Farmers Association;
- Ballina Fisherman's Cooperative;
- Aboriginal Community;
- Oyster growers;
- Community Representative; and
- Environmental Representative.

The Richmond River Estuary Technical Team consists of key personnel from the local government areas within the estuary and agency stakeholders including the councils, OEH and DPI (Fisheries, Crown Lands and CMA) representatives.

The Technical Team met on a regular basis to discuss on-going estuary management projects and provide feedback on the development of the Draft EMS and Draft CZMP.

2.3 Regional and Local Management Plans and Policies

Management plans and policies that apply to the Richmond River estuary include (refer Appendix 1):

- Estuary General Fisheries Management Strategy, 2003;
- NSW Sea Level Rise Policy Statement, 2009;
- Floodplain management plans for the management area;
- NSW Coastal Policy;
- Northern Rivers Regional Biodiversity Management Plan, National Recovery Plan for the Northern Rivers Region (DECCW 2010);
- NSW Wetland Policy, 2010;
- NSW Diffuse Source Water Pollution Strategy, 2009;
- Northern Rivers Catchment Action Plan, 2006 (refer Section 2.2.3);
- Interim Water Quality and River Flow Objectives;
- Draft Water Sharing Plan for the Richmond River Area unregulated, regulated and alluvial water sources;
- National Parks and Reserves Plans of Management;
- Health Rivers Commission Inquiry into NSW Coastal Lakes, 2002;
- Northern Rivers Farmland Protection Project, 2005;
- Far North Coast Regional Strategy 2006 – 2031;
- Far North Coast Regional Conservation Plan (Draft), 2009;
- Evans River Estuary Management Plan, 2002;
- Evans Head Coastline Hazard and Estuarine Water Level Definition Study;
- Wilsons River Catchment Management Plan 2009;
- Crown Reserves Plans of Management (Woodburn, Coraki and Evans Head); and
- Northern Rivers Biodiversity Management Plan, 2010.

2.4 Planning Instruments

Planning and development in NSW is carried out under the Environmental Planning and Assessment Act 1979 and Environmental Planning and Assessment Regulation 2000. Environmental planning instruments (state environmental planning policies, SEPPs and local environmental plans, LEPs) are legal documents that regulate land use and development. Relevant SEPPs include (refer Appendix 1):

- North Coast REP (1988) – deemed a SEPP;
- Rural Lands, 2008;
- Remediation of Land, 1998;
- Building Sustainability Index (BASIX), 2004;
- Infrastructure, 2007;
- Major Development, 2005;

- SEPP 71 Coastal Protection;
- SEPP 62 Sustainable Aquaculture;
- SEPP 44 Koala Habitat Protection;
- SEPP 26 Littoral Rainforests;
- SEPP 19 Bushland in Urban Areas; and
- SEPP 14 Coastal Wetlands.

Strategic plans prepared by the local Councils guide local management strategies. These are discussed further in Appendix 1.

LEPs guide planning decisions for local government areas. Through zoning and development controls, they allow councils to supervise the ways in which land is used. Ballina Shire, Lismore City and Richmond Valley Councils have prepared Draft LEPs in accordance with the new Standard Instrument which sets out 35 standard zones for councils to use when preparing new LEPs for their LGAs. The new LEPs are currently being finalised.

Types of zones relevant to the estuary include rural, residential, business, industrial, special purpose (tourist), recreation, environment protection and waterway zones. For each zone, the Standard Instrument sets out 'core' objectives for development, and certain mandated permitted or prohibited land uses.

Relevant Environment Protection zones include:

- E1 National Parks and Nature Reserves - All uses currently authorised under the National Parks and Wildlife Act 1974 are permitted without consent in this zone;
- E2 Environment Conservation - intended to protect land that has high conservation values outside the national parks and nature reserve system;
- E3 Environmental Management - intended to be applied to land that has special ecological, scientific, cultural or aesthetic attributes, or land highly constrained by geotechnical or other hazards; and
- E4 Environmental Living - intended for land with special environmental or scenic values, and accommodates low impact residential development.

Relevant Waterway zones include:

- W1 Natural Waterways - intended for natural waterways that are to be protected for their ecological and scenic values; and
- W2 Recreational Waterways - includes water-based recreation, boating and water transport, and development associated with fishing industries, such as natural water-based aquaculture and recreational fishing.

Development Control Plans, prepared in accordance with the Environmental Planning and Assessment Act, are also used to help achieve the objectives of local plans (including LEP and CZMPs) by providing specific, comprehensive requirements for certain types of development or locations. DCPs include provisions for vegetation management, development on the floodplain, tourist developments, coastal hazard protection, stormwater management, acid sulfate soils, water sensitive design and buffer areas.

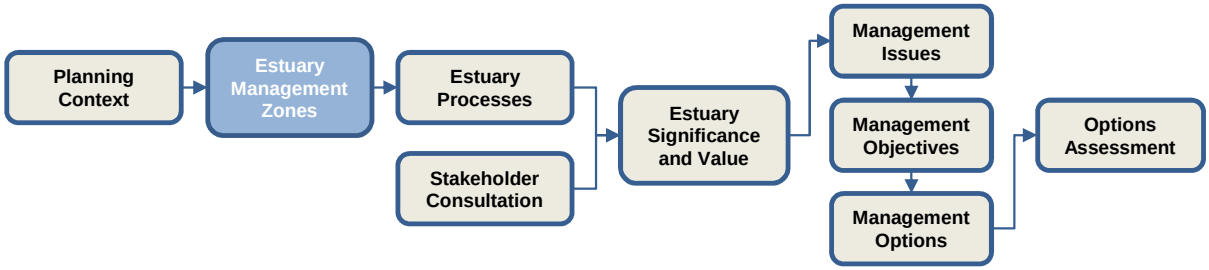
2.5 Relevant Legislation

Legislation relevant to the estuary management planning process is listed below (refer Appendix 1):

- (Commonwealth) Environment Protection & Biodiversity Conservation Act, 1999;
- Environmental Planning & Assessment (EP&A) Act, 1979;
- Coastal Protection Act, 1979;
- Local Government Act, 1993;
- Protection of the Environment Operations Act, 1997;
- Fisheries Management Act, 1994;
- Crown Lands Act, 1989;
- Marine Parks Act, 1977 and Marine Park Regulation, 2009 and Marine Parks (Zoning Plans) Regulation, 1999;
- Water Management, Act 2000;
- Catchment Management Authorities Act, 2003;
- Native Vegetation Act, 2003;
- Threatened Species Conservation Act, 1995;
- National Parks and Wildlife Act, 1989 (1974);
- Heritage Act, 1977;
- Noxious Weeds Act, 1993;
- Native Title (New South Wales) Act, 1994; and
- Soil Conservation Act, 1938.

Legislative requirements will be considered in the development of estuary management options (refer Section 7).

3. ESTUARY MANAGEMENT ZONES



This Section discusses the major features and values of the estuary management zones and introduces the issues in each zone.

The Richmond River estuary management zones are:

Zone 1 - North Creek;

Zone 2 - Emigrant / Maguires Creek;

Zone 3 – Back Channel;

Zone 4 – South Ballina/Empire Vale;

Zone 5 – Riley's Hill;

Zone 6 – Evans River;

Zone 7 – Rocky Mouth Creek;

Zone 8 – Swan Bay;

Zone 9 – Kilgin/Buckendoon;

Zone 10 – Tuckean;

Zone 11 – Lower Bungawalbin; and

Zone 12 – Upper Richmond/Wilsons River.

3.1 Management Zones

Given the large size of the study area (floodplain approximately 1,000 km^2) and the three local government jurisdictions, twelve Management Zones were developed by the Richmond River Floodplain Committee in 2007. The zones align with sub-catchments or with a part of the floodplain that is segregated by geography or infrastructure boundaries such as roads. The zones were selected as reasonable areas in which to base and enable natural resource management activities. The objective was to provide a manageable breakdown of the estuary area to facilitate implementation of the management actions. The 12 estuary management zones are shown in Figure 7.

The major features of each zone are discussed in the following sections including an introduction to the key management issues, a figure showing the major features of the zone and a figure showing the management issues within the zone. This information has been collated from background data including the Estuary Processes Study (EPS - WBM, 2006), consultation activities, knowledge of the estuary and input from the Technical Team (refer Section 2.2.4). This is provided as an indication of estuary management issues rather than comprehensive mapping of the extent and location of the issues. Further discussion on the estuary processes is provided in Section 4. Section 7 provides further discussion of relevant issues and options for management.

Land use mapping sourced from DECCW (2009) has been used to characterise the study area and while every effort has been made to produce accurate mapping, the data is not guaranteed to be free from error, and as land use is continually changing, this data should be viewed as a guide only.

3.2 Zone 1 - North Creek

North Creek is a shallow water ecosystem stretching from the marine dominated shoals adjacent to Ballina, through the upper estuarine swamps of the Ballina Nature Reserve, to the extensive freshwater floodplain of Newrybar Swamp. This waterway forms the north-east arm of the Richmond River estuary (Figure 8). This zone is within the BSC local government area.

The North Creek/Newrybar Management Zone comprises mostly agricultural land use (cane, grazing and increasing areas of macadamia) which is located in the upper parts of the catchment (behind Lennox Head and below Newrybar). The hydrology of this area has been modified by extensive drainage works and levee construction. The Union Drain enters the upper reaches of North Creek and the Newrybar Levee lies north of Ballina Nature Reserve (refer Figure 9).

The urban areas of Ballina including several industrial estates are situated in the lower reaches. Stormwater runoff has been identified as a potential source of contaminants in North Creek. The West Ballina Sewage Treatment Plant (STP) discharges treated wastewater to North Creek Canal in the south west of the Zone. Lennox Head STP is situated within this zone, north of Ballina and discharges treated wastewater via a pipeline to the Pacific Ocean.

The Ballina Nature Reserve occupies a large area in the mid-section of North Creek and provides habitat for a range of flora and fauna, including threatened species. The reserve comprises a wetland that contains mangroves, swamp sclerophyll forest and saltmarsh communities (NPWS, 2003). The mid and lower reaches of the zone are valued recreational areas used by local residents and tourists for fishing, boating and swimming. Sandy shoals in lower North Creek and the Richmond River adjacent to Ballina provide sheltered and unique environments for recreation. The lower estuary is a designated recreational fishing haven with the exception of the Mullet dig at Missingham Bridge which is fished by commercial fishers at certain times of the year. Commercial oyster culture occurs in North Creek and Mobbs Bay in South Ballina. Boat launch facilities are located at several points in this zone and WBM (2006) noted access issues due to high use of existing facilities at busy times of the year.

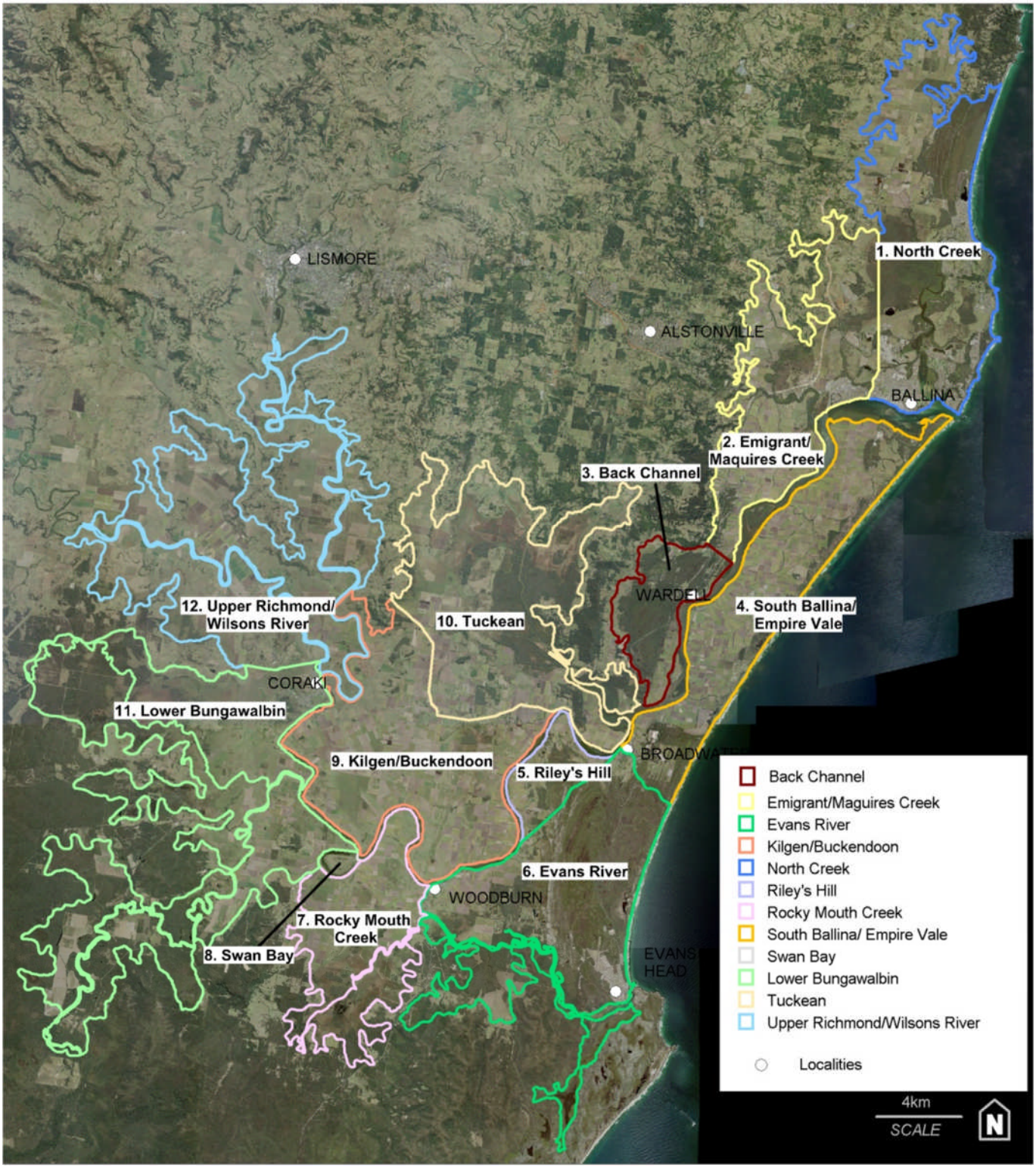


Figure 7 - Richmond Estuary Management Zones

Plate 1: Recreational users at the sand spit in the Richmond River near the Ballina Sailing Club

In the lower reaches of North Creek and the Richmond River, the majority of the shoreline is highly modified by urban development. Rock walls line much of the lower estuary shoreline to protect against bank erosion. Fragments of relatively extensive intertidal mangrove forest/saltmarsh remain. The lower reaches of North Creek also contain large inter-tidal sand shoals which are important feeding and roosting sites for resident and migratory shorebirds. Intertidal mangrove forests in North Creek constitute important nursery and feeding habitat for a diverse range of juvenile fish species. Good riparian vegetation cover exists along the middle reaches of North Creek and the vegetated zone is mostly greater than 50m wide with a high native cover in the canopy (>30% - 60%) (Australian Wetlands, 2010).

Plate 2: Lower North Creek

In the higher reaches above Ross Lane, the Creek has been channelised by drainage works. With the exception of pasture grasses and a few patches of regrowth upstream, riparian vegetation is almost non-existent on the channel. One exception of note is a 750m stretch of drain where a successful riparian planting trial has provided vegetated riparian zone for this section.

Large areas of the upper and mid reaches of this zone are identified as high risk ASS (ASS, Tulau, 1999). There is evidence of ASS runoff affecting the upper reaches of the North Creek estuary for periods following smaller runoff events during the wet season when groundwater levels are relatively high (ABER, 2008). Acidification is generally buffered by seawater flushing in the lower sections and is not a significant issue. Issues with low dissolved oxygen (DO) concentrations were also noted to increase upstream along North Creek. ABER (2008) indicated that DO concentrations were likely to be driven by high organic loads from groundwater inputs, leaf litter fall and deposition of algal blooms during summer. High nutrient concentrations combined with high temperatures noted in water quality results, were expected to be the main driver of the occurrence of algal blooms in summer. In addition, high faecal coliform levels in the lower reaches of North Creek have caused the extended closure of oyster harvest areas, and are threatening the viability of this industry (WBM, 2006). The source of pathogens is not currently known.

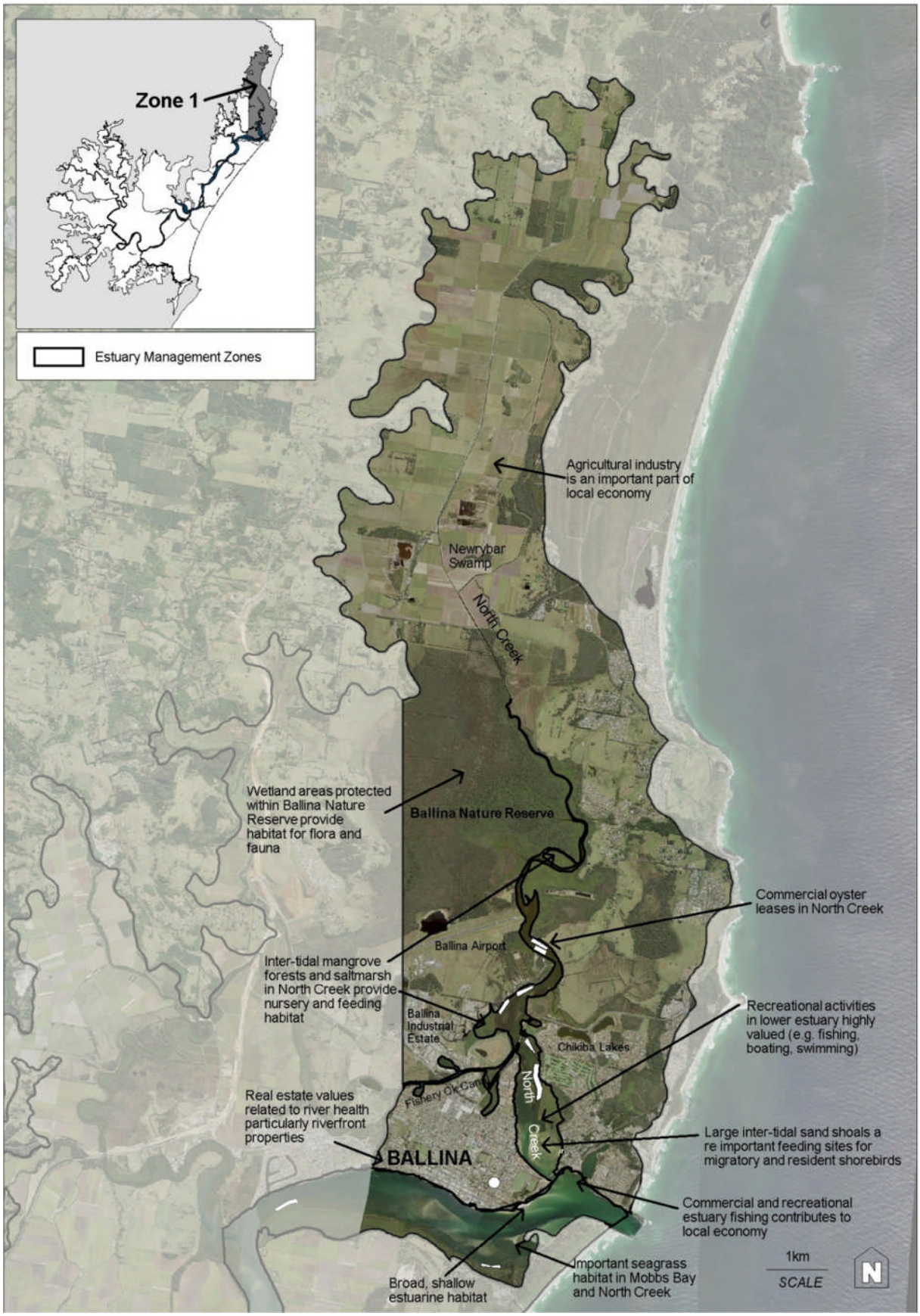


Figure 8 – Zone 1 North Creek/Newrybar: Major Features

Source: aerial photography provided by RRCC

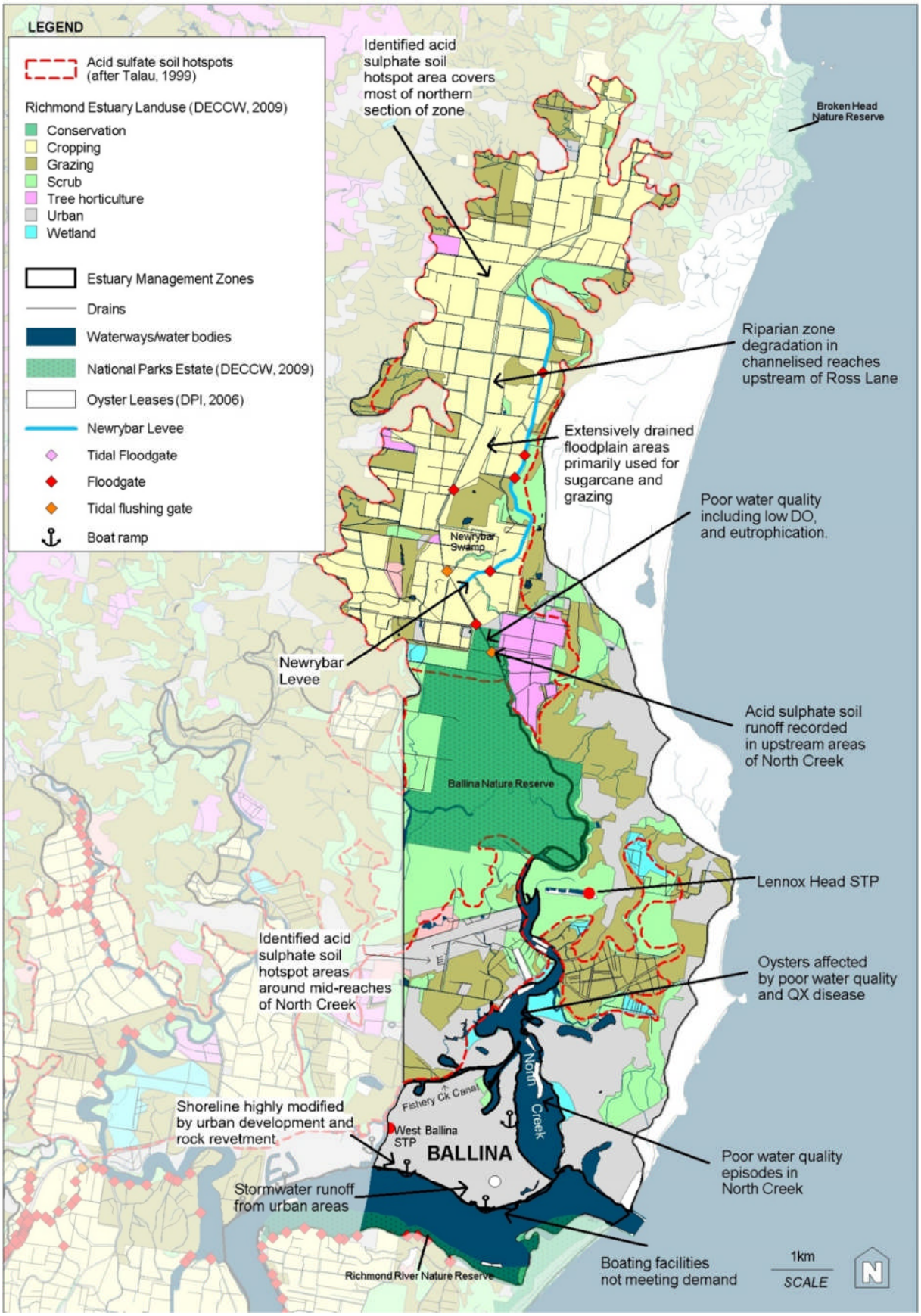


Figure 9 - Zone 1 North Creek/Newrybar: Management Issues

3.3 Zone 2 - Emigrant / Maguires Creek

This zone is within the BSC local government area. It includes the sub catchments of Emigrant Creek and Maguires Creek. Emigrant Creek is a shallow water ecosystem stretching from the marine dominated shoals at its confluence with the main Richmond River estuary, through the floodplain backswamps immediately north of the Pacific Highway, to the upper estuarine reaches traversing alluvial floodplains. In its upper reaches, Emigrant Creek Dam forms part of the town water supply catchment for Ballina and Lennox Head.

Maguires Creek drains from the Teven Valley and part of the Alstonville Plateau and intersects with Emigrant Creek approximately 7.5kms upstream of the confluence with the Richmond River. The lower estuarine reach also receives inputs from the Uralba floodplain to the south via Duck Creek (Figure 10).

Land use in the area is predominantly agricultural with sugar cane and some grazing on the floodplain and lower lying areas, and macadamia farming and some mixed horticulture on the higher areas. The floodplain has been extensively drained and many floodgates have been installed which greatly affects water flows and quality. The Ballina Bypass and proposed Tintenbar to Ewingsdale upgrade of the Pacific Highway also has potential implications for water quality in this zone during the construction phase.

Urban areas are located in the lower reaches and comprise West Ballina and the Ballina Quays canal estate. Commercial oyster leases exist in the Richmond River adjacent to this zone. The freshwater reach of Maguires Creek receives treated wastewater from the Alstonville STP. Boat launch facilities, a slipway and limited mooring sites exist in the lower sections of Emigrant Creek. Current boating facilities are not meeting demand (GHD, 2005).

Plate 3: Active erosion of topsoil from young Macadamia plantation

Source: P. Dwyer

The lower estuarine areas of Emigrant Creek are fringed with mangrove areas in good condition (Australian Wetlands, 2010). The riparian width varies from 50m wide to less than 10m where landuse

or roads come close to the creek edge. There are some areas of bank erosion in this reach identified as being impacted by boat wash. The riparian zone along much of the main Richmond River Channel is generally devoid of vegetation, with rock walls providing the only protection against bank erosion for much of the length.

The lower Emigrant Creek estuary downstream of the Pacific Highway Bridge contains significant shallow water shoals with a significant area of seagrass at the confluence with the main Richmond River Estuary. The shoals provide feeding and nursery habitat to various fish and other vertebrate and invertebrate species. The Creek is more dominated by freshwater than North Creek reflecting the greater in-filling of the lower floodplain, and higher freshwater inflows. The lower reaches of the system are also impacted by flood tide inputs of catchment runoff water from the main Richmond River estuary during high and post-high flow periods.

The mid and upper sections of this zone are identified as an ASS Hotspot (Tulau, 1999). Acid water runoff has been noted as affecting water quality in the mid and upper reaches, however tidal flushing in the lower reaches largely mitigates this issue.

The Ballina Quays Canal Estate located in West Ballina has been observed to be a confounding factor in blackwater fish kills. The design of the canals is such that it captures blackwater flow from the Richmond River cutting off fish escape and resulting in fish kills in the canals. Plate 4 shows a distinct blackwater plume entering the estate.

Plate 4: Blackwater plume entering Ballina Quays Estate after a moderate summer flood in January 2006

Source: C. Cooksey, 2006

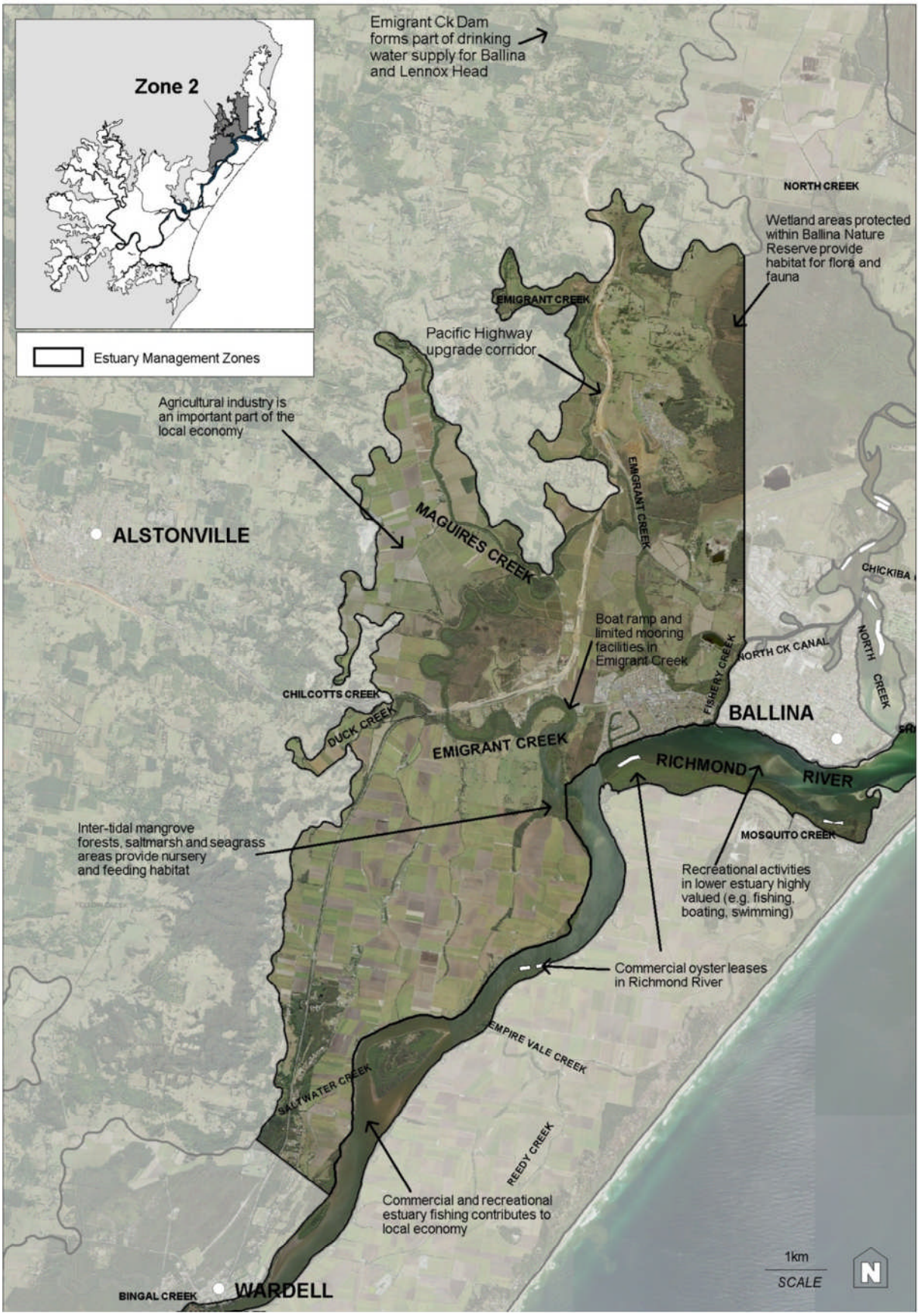


Figure 10 – Zone 2 Emigrant/Maguires Creek: Major Features

Source: aerial photography provided by RRCC

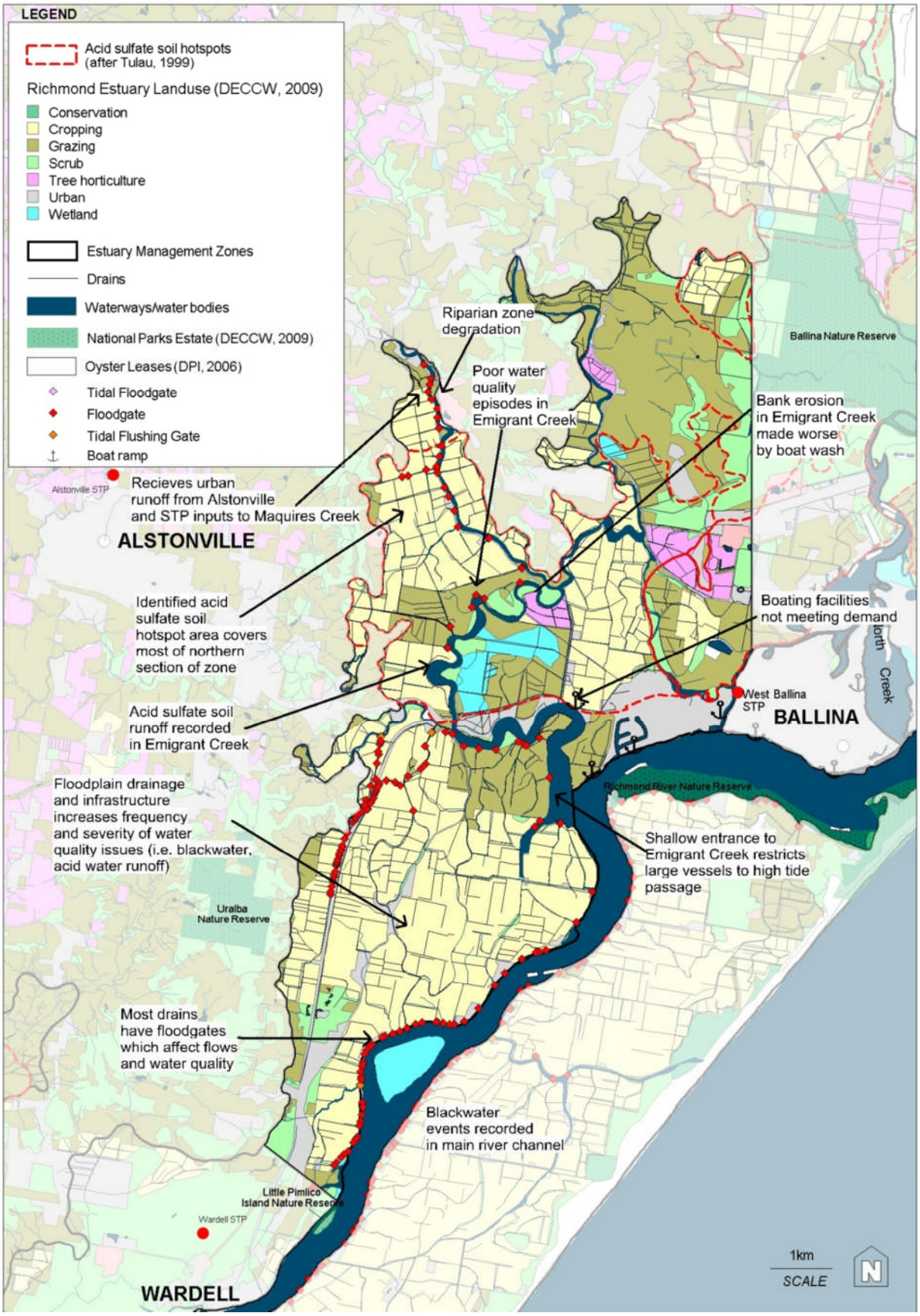


Figure 11 - Zone 2 Emigrant/Maguires Creek: Management Issues

3.4 Zone 3 – Back Channel

The Back Channel management zone is located on the western bank of the main Richmond River Estuary adjacent to Wardell, within the Ballina local government area. It has a discrete catchment bounded from the south, west and northwest by the Blackwall Range (refer Figure 12).

This zone consists of floodplain cleared for agriculture in the upper section with a large Crown Reserve in the middle parts, and estuary in the lower reaches. The Crown Reserve comprising remnant heath/swamp vegetation is drained by small channels feeding Bingal Creek, which enters the Richmond River Estuary just upstream of the Wardell Pacific Highway Bridge. A large area of cane farming exists south of Wardell, extending to the bank of the Richmond River. Urban areas of Wardell and small grazing leases make up the remaining areas. Wardell STP discharges treated wastewater to the Richmond River downstream of the main town. The proposed route for the Pacific Highway upgrade traverses the alluvial floodplain, although work has not begun on this section to date. Several quarries also exist in the southern end of this zone.

The Back Channel management zone includes the bank of the Richmond River near Wardell. The northern bank of the river has a healthy mature (>10 year old) corridor of mangroves and riparian vegetation with 30-60% native cover in the canopy and understorey (Australian Wetlands, 2010). On the southern side, the riparian vegetation is very narrow to non-existent in places. The riparian vegetation on the southern side includes remnant mangroves and saltmarsh. The major issues affecting the recolonisation of mangroves are boat wash and encroaching land use.

Bingal Creek is a shallow waterway that flows into the main Richmond River channel above Wardell. Along its banks, intertidal mangrove wetlands (up to 60m wide) extend approximately 2.5km upstream of Wardell.

There are relatively few issues identified for this zone due primarily to the large areas of intact vegetation located within the Crown Reserve, occupying much of its area. Bingal Creek represents a rare example of what many of the flood-gated creeks to the Richmond would have looked like in a more natural state. Due to the relatively sparse representation in the main channel, Bingal Creek represents valuable wetland habitat for fish and invertebrates and it will be important to conserve this existing area into the future. One exception is some of the intertidal habitat in this reach of the main estuary which has been reduced by clearing and in-filling for sugarcane production (WBM, 2006).

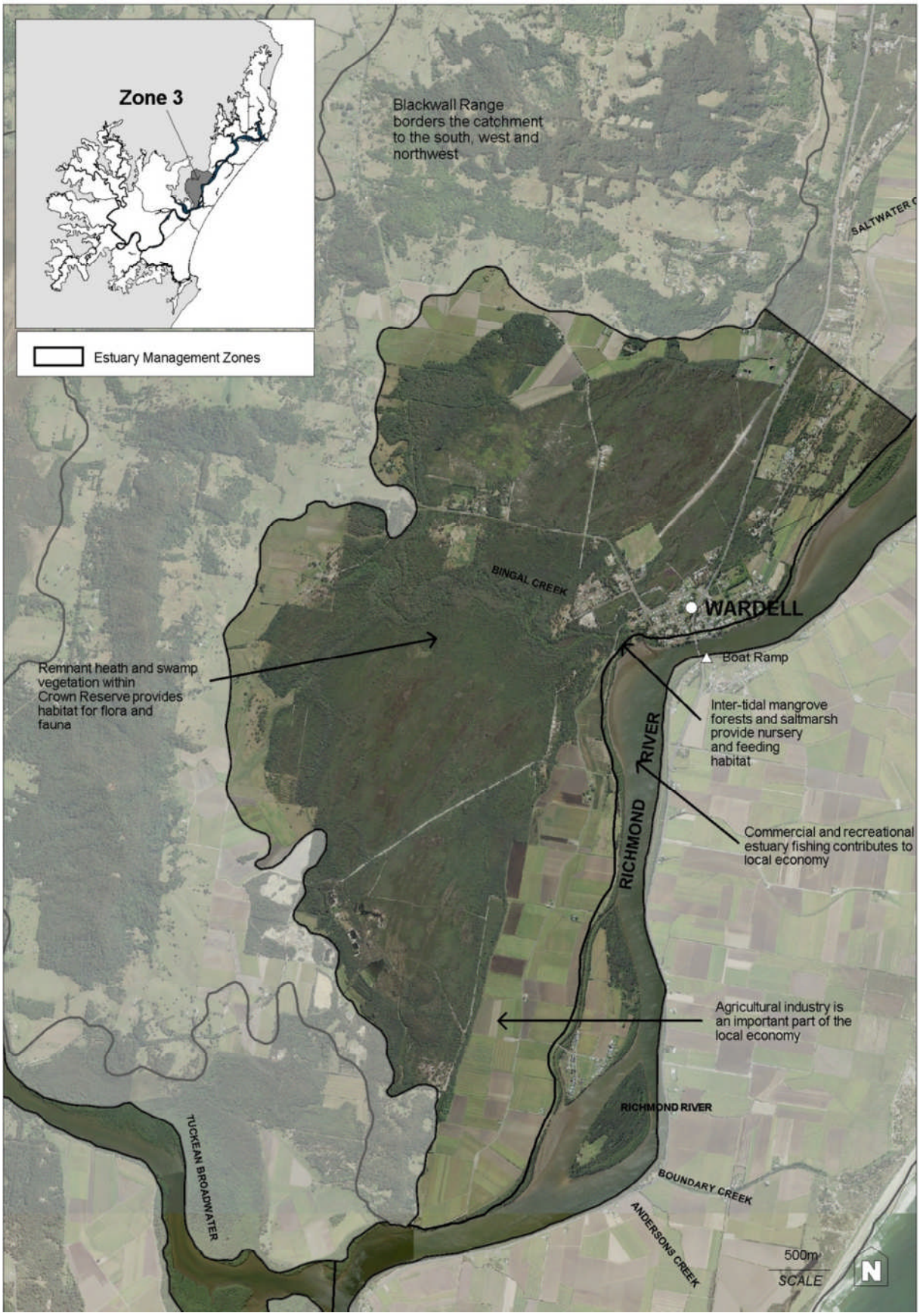


Figure 12 – Zone 3 Back Channel: Major Features

Source: aerial photography provided by RRCC

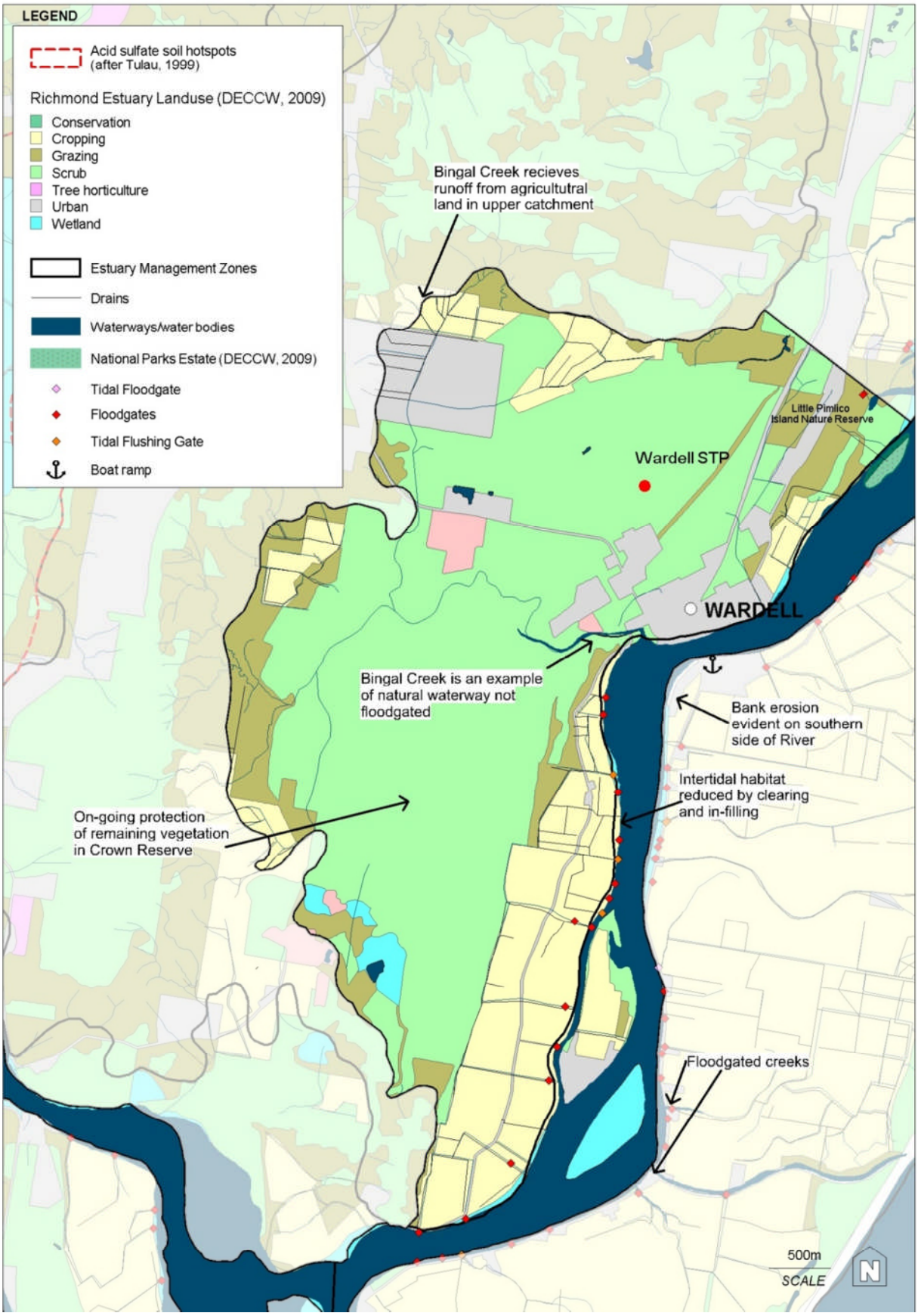


Figure 13 – Zone 3 Back Channel: Management Issues

3.5 Zone 4 – South Ballina/Empire Vale

The South Ballina / Empire Vale management zone encompasses extensive floodplain on the eastern side of the estuary stretching from South Ballina to Broadwater. The floodplain includes barrier dune ridges along its eastern fringe and predominantly alluvial sediments across the bulk of the floodplain. This northern part of this zone is within the BSC local government area and the southern section south of Boundary Creek is within the Richmond Valley council area.

Sugar cane farming accounts for the majority of the land area within this zone. Grazing, rural residential areas and fragmented conservation areas make up the remainder of land uses. Drainage of the floodplain is enhanced by a network of highly modified natural drainage depressions which discharge to the main Richmond River channel at various locations. Tidal exchange into these channels is controlled by tide gates at the confluence with the main river channel. Mangroves are extensive within the Richmond River Nature Reserve along the Richmond River adjacent to South Ballina Beach Road. Several large floodgates feed into the river along the zone. Mobbs Bay is a high use area for recreational boaters, jet skiers, water skiers and fishers and contains a significant roosting and breeding area for various resident and migratory shorebirds and important areas of seagrass and some commercial oyster leases. Scattered stands of casuarinas, littoral rainforest and seasonal wetlands form important habitat along the eastern (coastal) fringe of this zone.

Plate 5: Mangrove community within Richmond River Nature Reserve

Empire Vale Creek enters the Richmond River Estuary at Pimlico Island and tidal exchange is controlled by tide gates at the confluence. The lower reach of Empire Vale Creek has intermittent bands of riparian forest up to 50m wide. Infield drains are largely devoid of riparian vegetation throughout the floodplain. The area to the north of Empire Vale Creek drains north via a series of constructed drains discharging in the Mobbs Bay reach of the lower estuary. A significant stand of intertidal mangroves (up to 140m wide) exists adjacent to the mouth of Empire Vale Creek. The remainder of the riparian zone along much of the main Richmond River Channel is generally devoid of vegetation. The river foreshore upstream of the Burns Point Ferry is rock armoured for most of its length.

The lower reaches of this zone are highly visible from the town of Ballina and contribute significantly to the aesthetic appeal of the estuary.

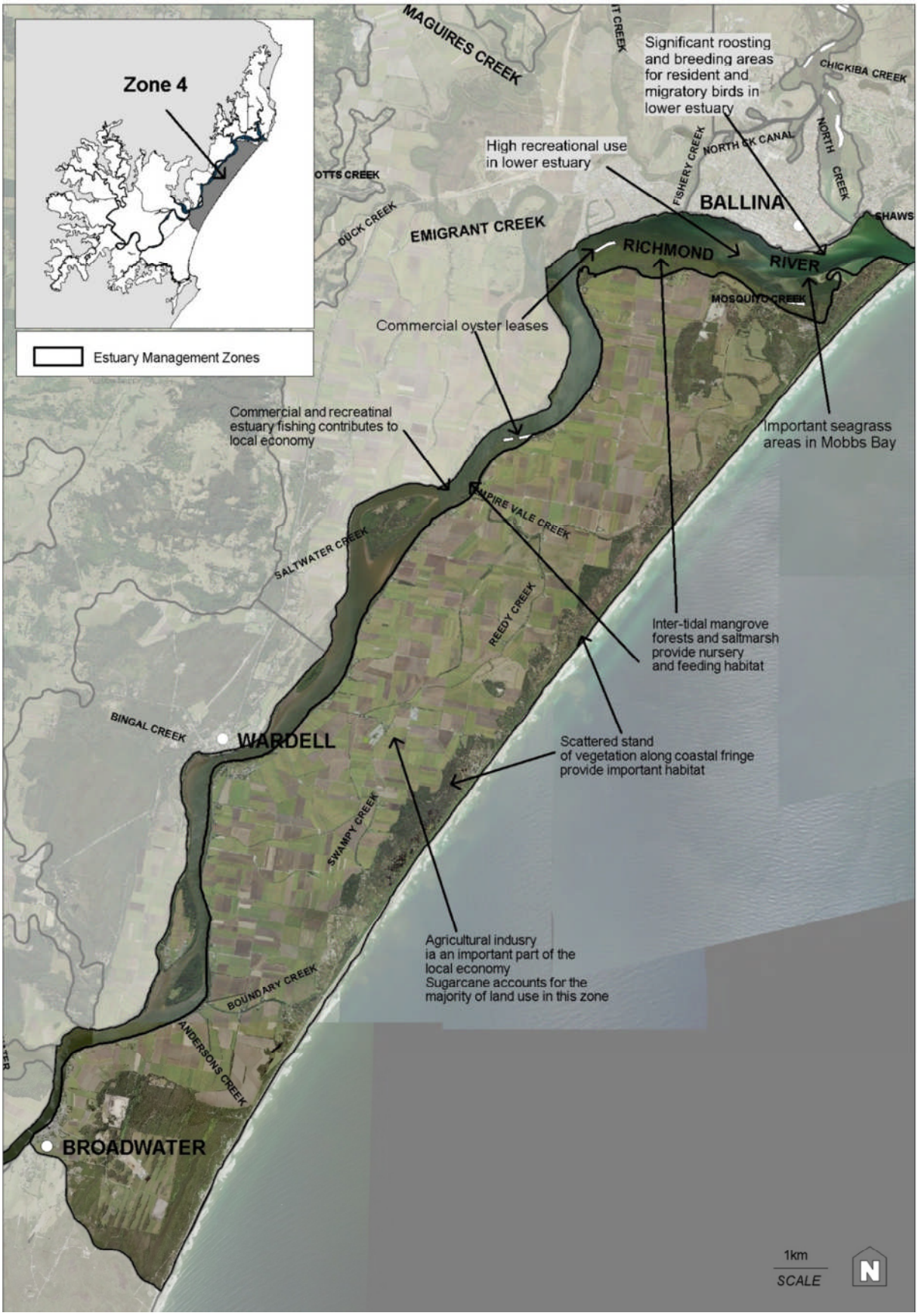


Figure 14 – Zone 4 South Ballina/Empire Vale: Major Features

Source: aerial photography provided by RRCC

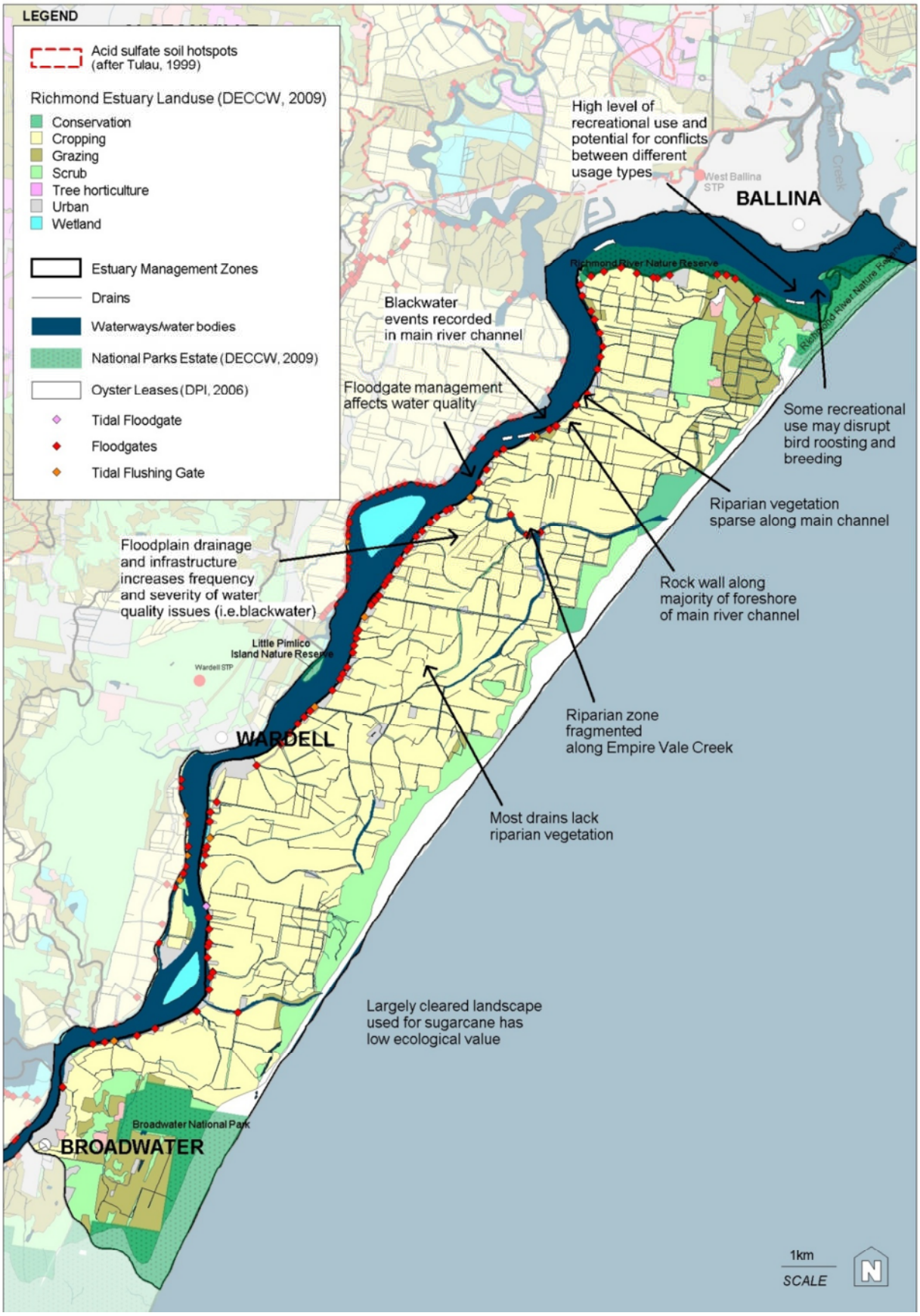


Figure 15 - Zone 4 South Ballina/Empire Vale: Management Issues

3.6 Zone 5 – Riley's Hill

The Rileys Hill Management Zone is relatively small in relation to other zones and is located upstream of Broadwater bordering the right bank of the Richmond River.

This zone is within the Richmond Valley council area and consists of cleared floodplain now used for sugar cane production, grazing and small areas of urban development. The north-west section of Broadwater National Park constitutes the central portion of this zone. Remnant vegetation protected within the National Park provides important habitat for flora and fauna including critical habitat for the endangered Oxleyan Pygmy Perch (Figure 16). The main Richmond River bank retains a fringe of mangroves for most of the management zone. Boat launch facilities exist in this zone and WBM (2006) noted access issues due to high use of existing facilities. The Riley's Hill STP discharges to the Richmond River upstream of Broadwater.

The riparian vegetation in this zone varies along the length of river bank from some coverage (riparian width >10m) with some remnant native vegetation to very limited cover. The understorey vegetation was degraded with few native species. Land use activities and road infrastructure are encroaching on the riparian zone. Drainage in this zone occurs via modified distribution channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Plate 6: Riley's Hill Boat Ramp

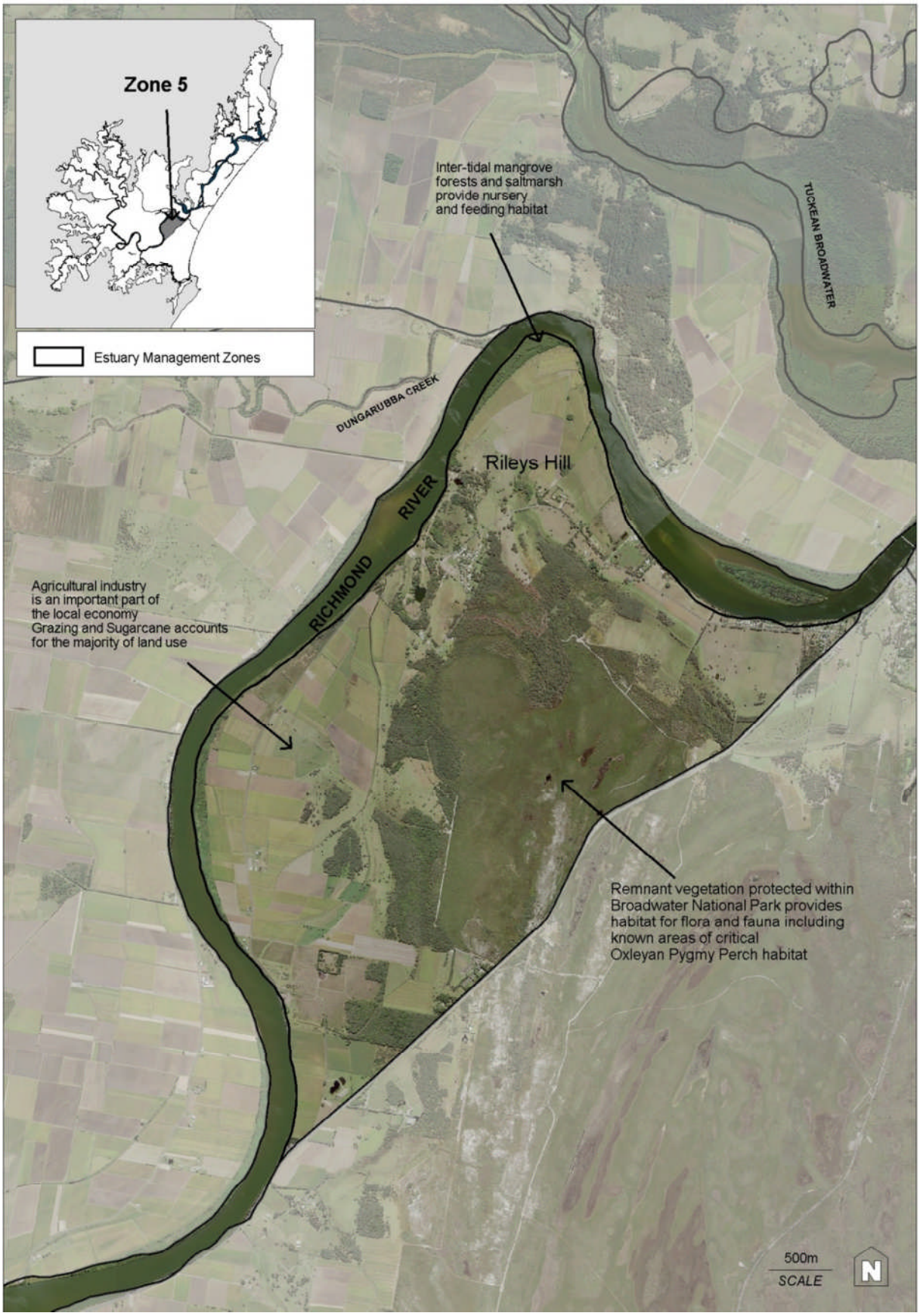


Figure 16 – Zone 5 Riley's Hill: Major Features

Source: aerial photography provided by RRCC

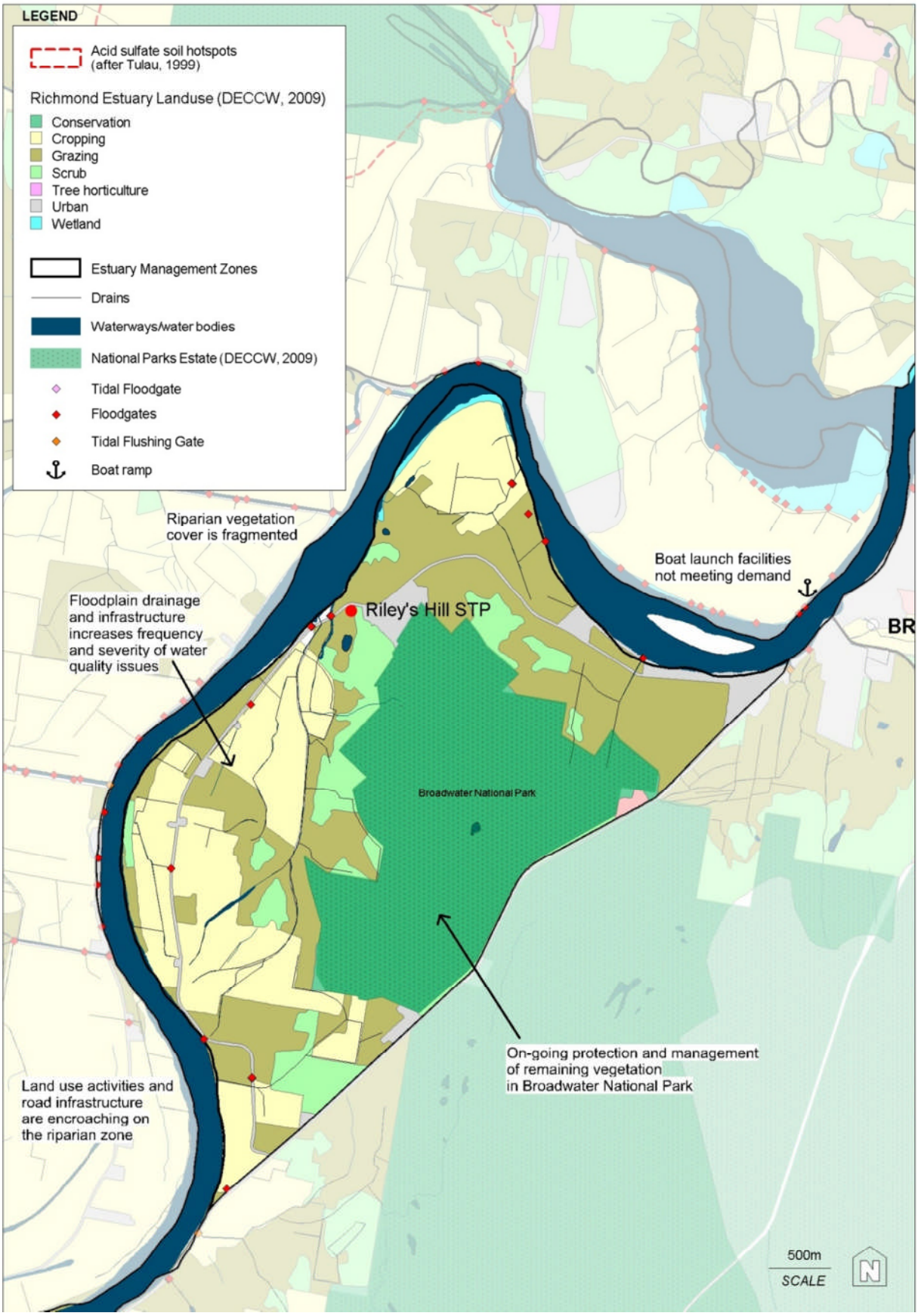


Figure 17 - Zone 5 Riley's Hill: Management Issues

3.7 Zone 6 – Evans River

The Evans River Management Zone extends from the ocean, west to the Richmond River bounded in the north by Boundary Creek and in the south by the Evans River floodplain. A major feature of this zone is the Tuckombil Canal which is an artificial channel connecting the Richmond River via Rocky Mouth Creek to the Evans River (Figure 18). Tuckombil Canal Weir effectively separates the Evans River and the Richmond River during normal flow reducing sediment transport and mixing. However during flooding it provides flood escape to the Evans River which lowers flood levels in the lower Richmond River. The Evans River Estuary Management Study and Plan was completed and adopted by Richmond Valley Council in 2002 and contains a suite of management actions for this estuary. This zone is within the RVC local government area.

Broadwater and Bundjalung National Parks make up a significant portion of the land area in this zone, with some cleared floodplain to the west and urban areas in Evans Head township which is located adjacent to the ocean entrance of the river. The western cleared floodplain originally covered in healthland and swamp vegetation is now used for agriculture including cattle grazing.

At the upstream end of the Evans River, former swamps were cleared and subsequently drained to form agricultural land. Lowering of the natural water table in these areas has increased acid runoff which can significantly lower the pH of the receiving waters, and along with low oxygen conditions, can lead to a stressed ecological environment (WBM, 2002). Vegetation along the Evans River is extensive in some areas but around the Tuckombil Canal, downstream of the Pacific Highway, there is no riparian canopy.

Plate 7: Bare riparian zone and active bank erosion along Tuckombil Canal

Sawpit Creek, Brandy Arm Creek and Oyster Creek drain the elevated ridgelines of the Evans River. A management plan for the Tuckombil Canal was completed by RRCC in 2009. It recommends the maintenance of the concrete weir installed in the canal in 2001 as a permanent structure.

RVC has completed an Estuary Processes Study (1999) and Estuary Management Study and Plan (2002) for the Evans River and is currently preparing the Evans Head Coastline Hazard and Estuarine Water Level Definition Study.

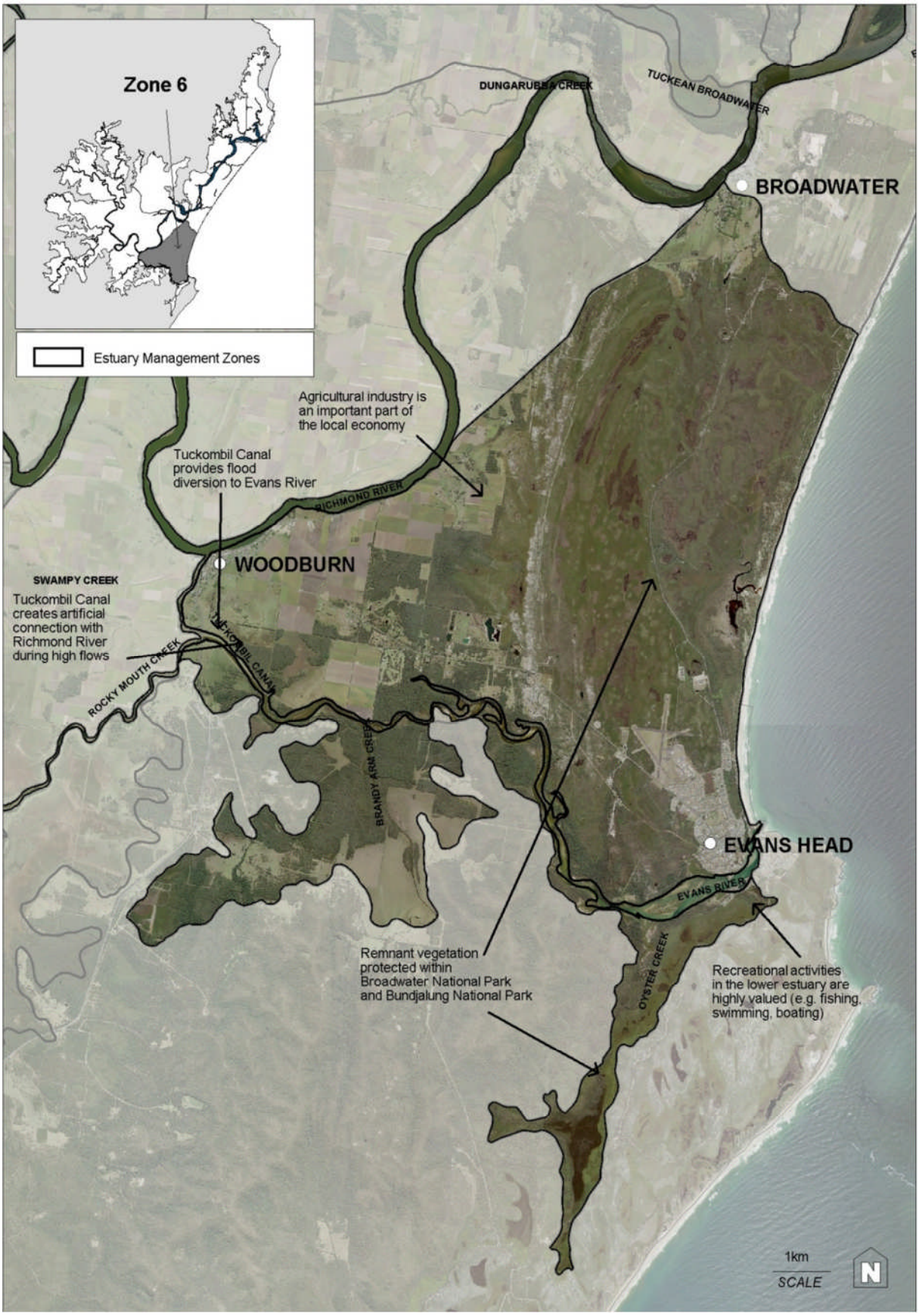


Figure 18 – Zone 6 Evans River: Major Features

Source: aerial photography provided by RRCC

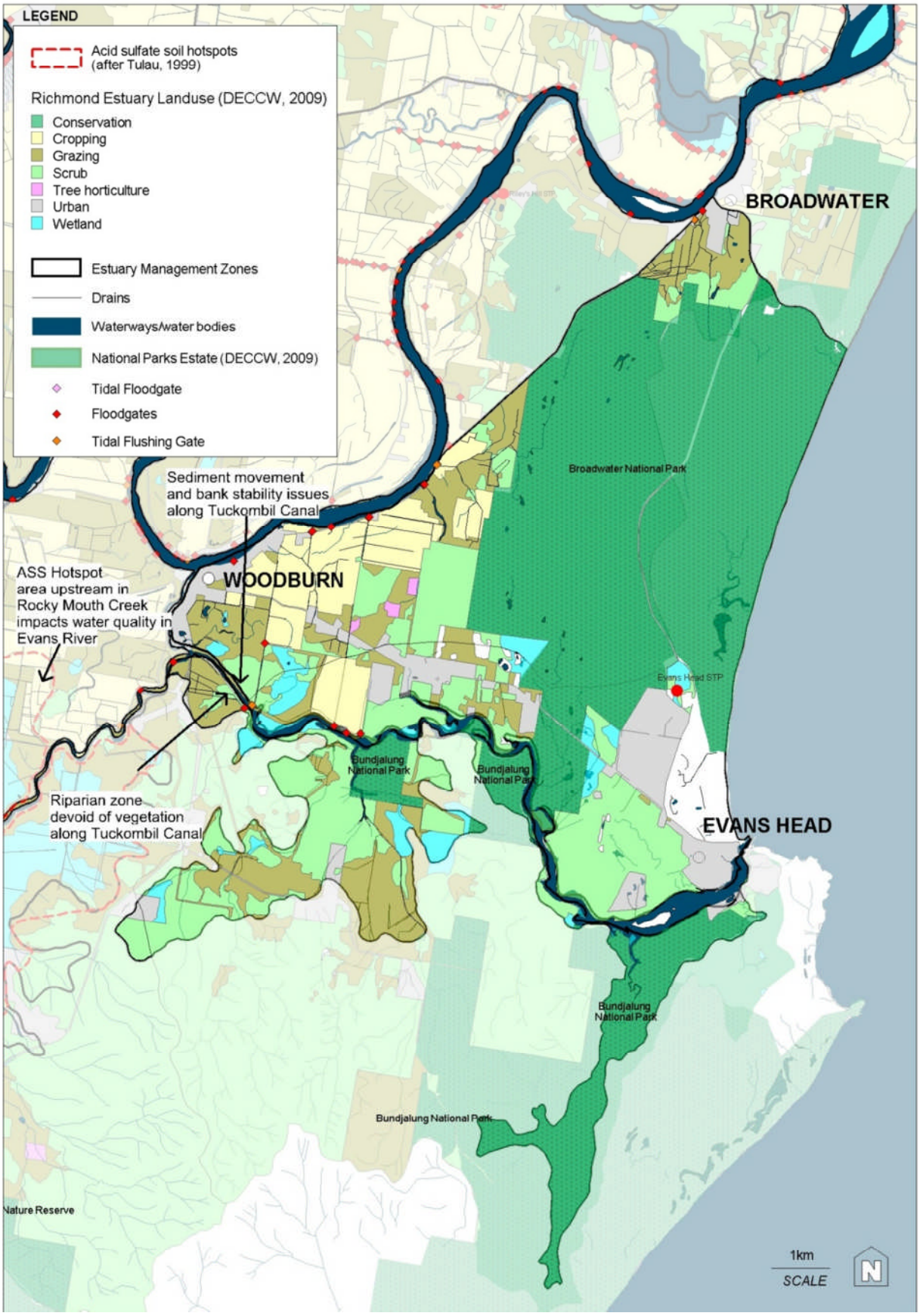


Figure 19 – Zone 6 Evans: Management Issues

3.8 Zone 7 – Rocky Mouth Creek

This zone comprises a low relief backswamp catchment draining via Rocky Mouth Creek to the confluence with the Richmond River Estuary at Woodburn. The backswamp floodplain is an in-filled estuarine embayment, and recent survey as part of the Richmond Flood Study has revealed the large backswamp basin has elevations of <1mAHD with some areas below sea level and subject to regular tidal movement. This zone is within the boundaries of Richmond Valley council area (Figure 20)

Significant drainage modification and riparian clearing has occurred in this zone. Current land use is dominated by cane farming and grazing. Eutrophication is common in the creek and high nutrient levels are likely to be caused by diffuse agricultural sources (ABER, 2008). There are extensive ASS deposits surrounding the south western reach of the creek. Drainage across the backswamp has been augmented by constructed drains which have led to widespread oxidation of ASS. Much of Rocky Mouth Creek Zone has been identified as an ASS hotspot area (refer Section 7.5.1). The backswamp areas of Rocky Mouth Creek have also been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010). At the time of high flow flood events there is considerable bank instability and erosion in this zone. Floodgates in Rocky Mouth Creek operate to limit inundation of the upper Rocky Mouth Creek catchment from Richmond River floods. In non-flood times the floodgates are opened to allow tidal flows for water quality improvements and fish passage.

The vegetation along the riparian zone of Rocky Mouth Creek is dominated by a weedy canopy of Cockspur Coral Tree (*Erythrina crista-galli*). Camphor Laurel (*Cinnamomum camphora*) is also a major canopy weed along Rocky Mouth Creek. The canopy cover is less than 30% with almost no native species. Pasture grasses dominated the understorey. Bank erosion is significant in areas devoid of vegetation.

Plate 8: Weed encroachment along Rocky Mouth Creek

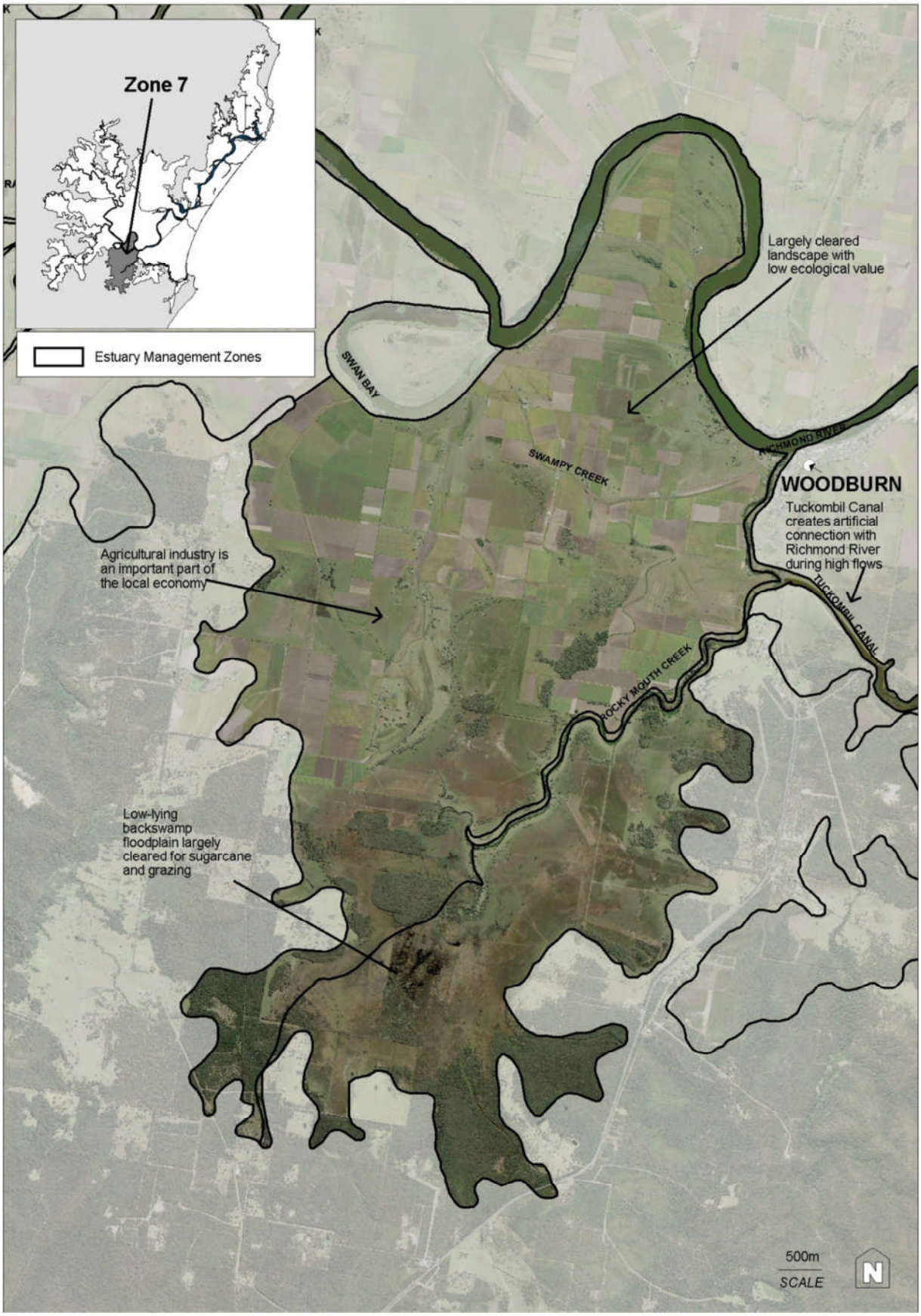


Figure 20 - Zone 7 Rocky Mouth Creek: Major Features

Source: aerial photography provided by RRCC

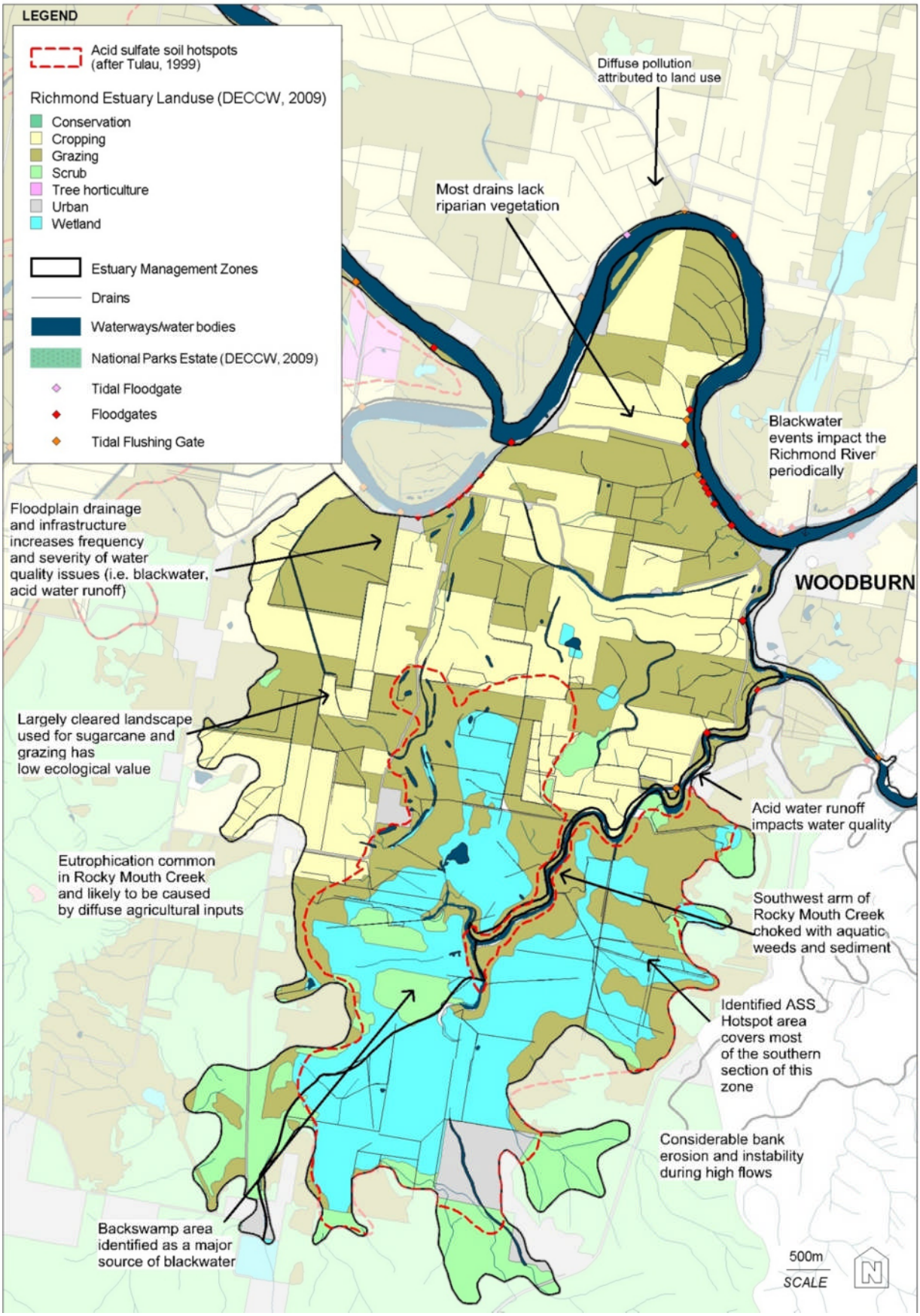


Figure 21 - Zone 7 Rocky Mouth Creek: Management Issues

3.9 Zone 8 – Swan Bay

Swan Bay is an oxbow partially cut-off lagoon, adjacent to the Richmond River, 8.3 km upstream of Woodburn, within the Richmond Valley council area (Figure 22). Its catchment constitutes a small part of the floodplain between the Rocky Mouth Creek backswamp and the lower Bungawalbin floodplain. Freshwater inputs to the bay are via four constructed drains. The downstream end of the bay is connected to the main estuary by a narrow channel. This waterway is recognised as an important fish nursery and water bird habitat.

Plate 9: Aquatic and Riparian weeds Swan Bay

Source: M. Wood

Swan Bay is surrounded by cattle grazing, tea tree and cane farming land where the native vegetation has been predominately cleared. The area is prone to weed and algae blooms indicative of nutrient enrichment and eutrophication. Periodic moderate acidification has been detected by water quality monitoring (ABER, 2008).

There is a narrow, fragmented riparian zone along the inland bank of Swan Bay, and no riparian zone along any of the drains (Australian Wetlands, 2010). Bank erosion is evident in areas devoid of riparian vegetation. Riparian vegetation on the northern bank of Swan Bay extending to the start of Swan Bay Road is dominated by native riparian species. The canopy cover is over 30% and up to 60% with a high percentage of native species.

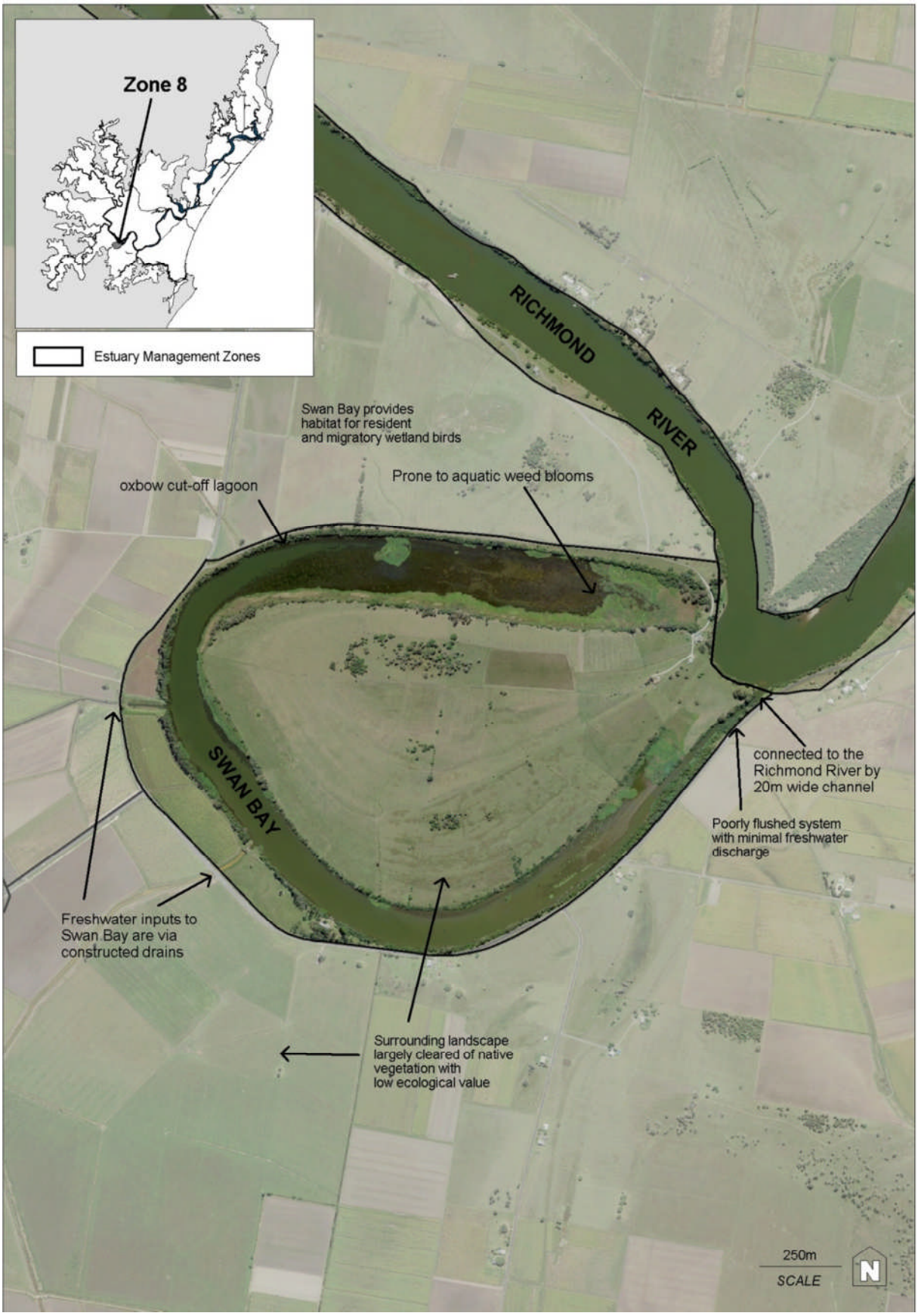


Figure 22 – Zone 8 Swan Bay Major Features

Source: aerial photography provided by RRCC

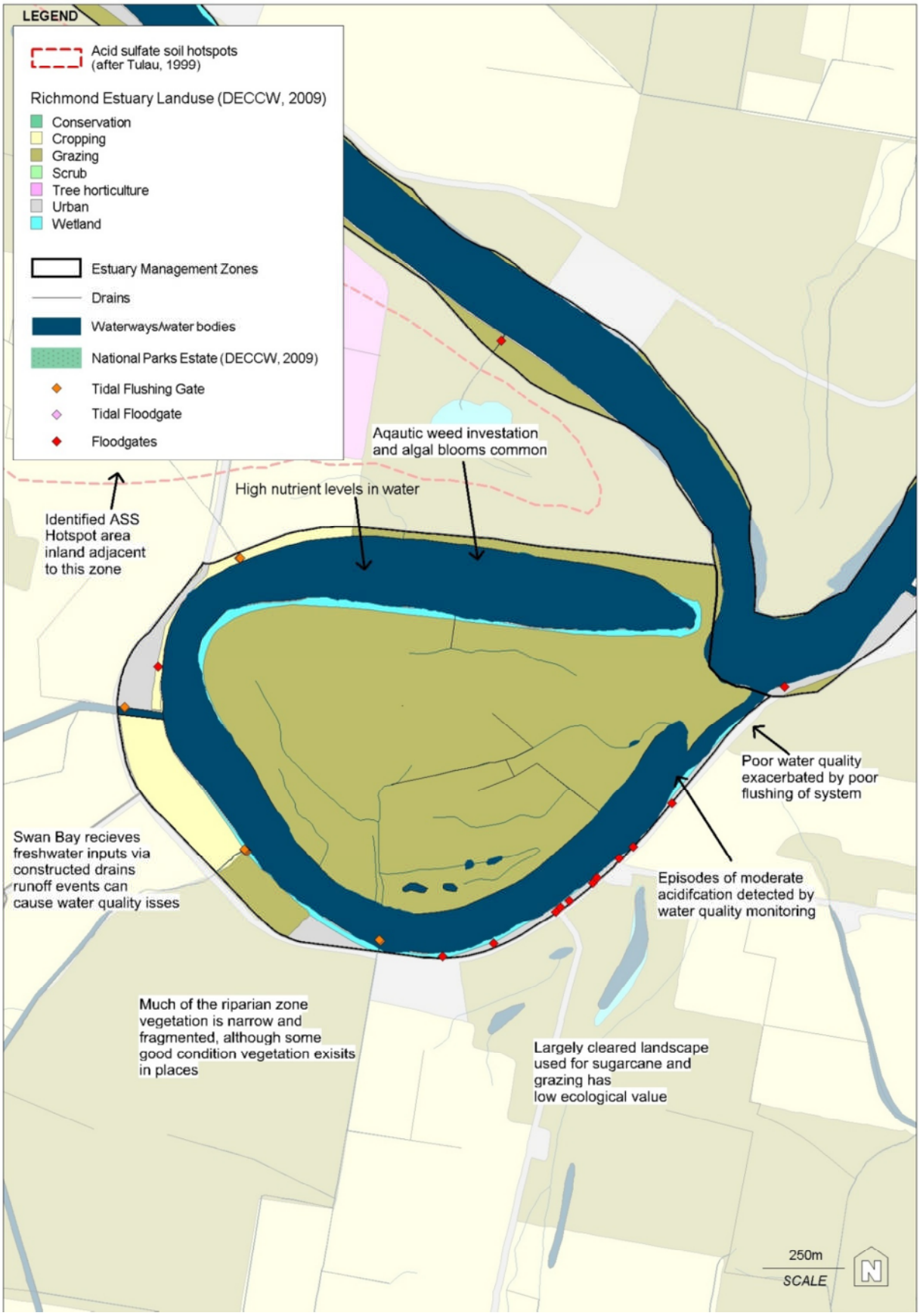


Figure 23 - Zone 8 Swan Bay: Management Issues

3.10 Zone 9 – Kilgin/Buckendoon

The Kilgin / Buckendoon management zone includes the Dungarubba area and comprises the extensive floodplain extending to Coraki to the west, and Woodburn in the south. This zone lies within the Lismore council area.

The floodplain has been extensively cleared of native vegetation. It contains large areas of relatively rich alluvial sediments which are currently under sugarcane, and large areas of estuarine backswamp sediments cleared for grazing. There are areas of ASS within these backswamps, although no hotspot areas have been identified in this zone. Acid water runoff from this and adjacent zones also affects water quality in the main river channel. The floodplain is drained by a network of constructed drainage channels and one natural creek line, Dungarubba Creek, entering the Richmond River Estuary via headworks spanning from Oakland Road to about 4.5kms upstream of Broadwater. This zone was identified by ABER (2008) as having a high risk of poor water quality, primarily associated with low dissolved oxygen.

There is little or no riparian vegetation along any of the drains, and the main river channel is also devoid of riparian vegetation for much of the length of this zone. Dungarubba Creek is the one example of a natural creek line with a largely intact riparian zone (Figure 24).

Plate 10: An isolated remnant of lowland rainforest on floodplain located on southern side of Tuckean Swamp at Dungarubba

Source: G. Owers, 2010

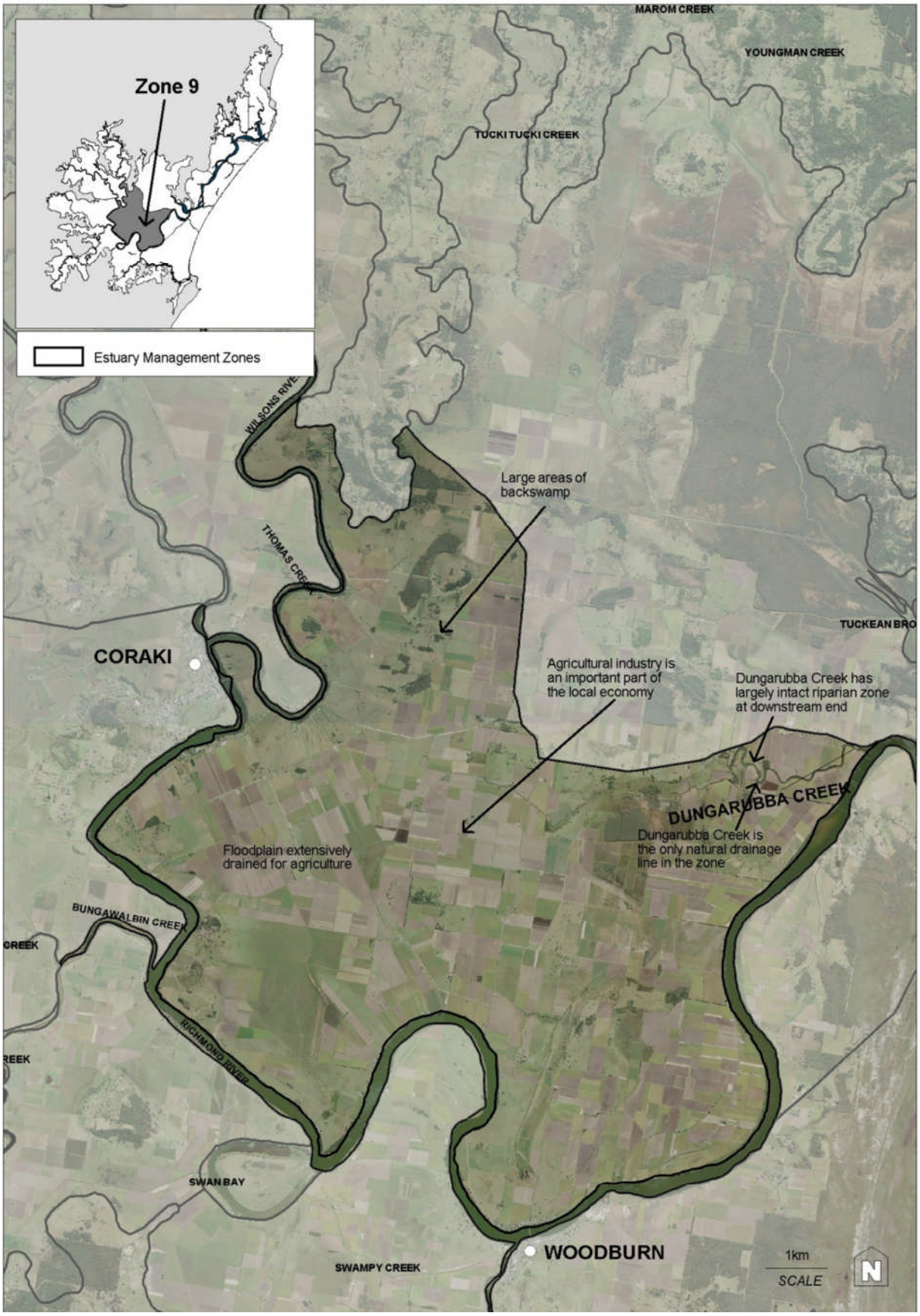


Figure 24 – Zone 9 Kilgin/Buckendoon: Major Features

Source: aerial photography provided by RRCC

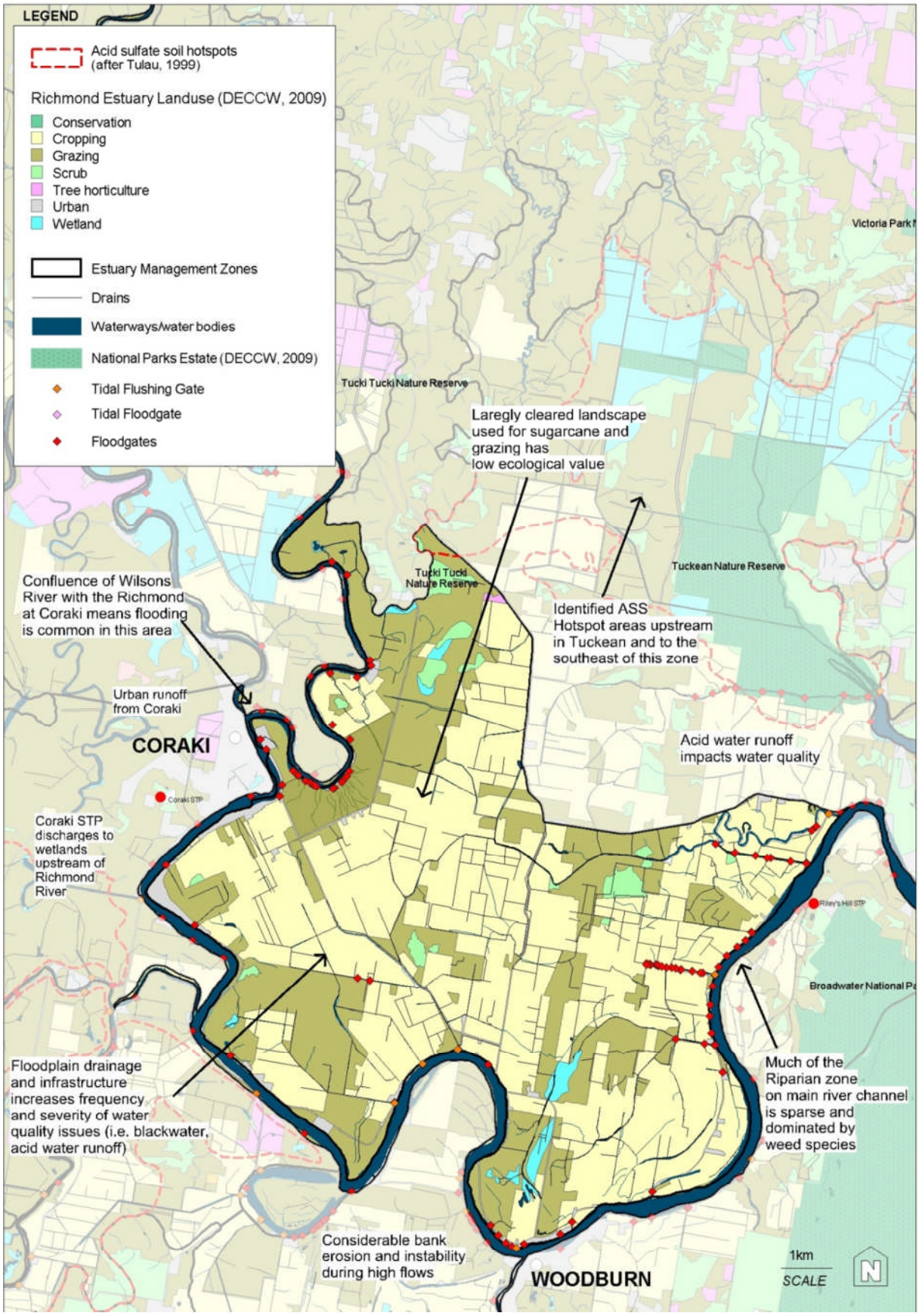


Figure 25 - Zone 9 Kilgin/Buckendoon: Management Issues

3.11 Zone 10 – Tuckean

Tuckean Swamp is an extensive, low-lying backswamp floodplain (5,000ha) receiving runoff via five creek systems from the upper catchment on the Alstonville Plateau (Marom Creek, Tucki Tucki Creek, Youngman's Creek, Gum Creek and Yellow Creek). The large backswamp areas are at elevations of mostly <1mAHD which is at or below sea level. Water exits the catchment via a tidal reach known as the Tuckean–Broadwater (Baldwin, 1997). A tidal barrage, known as the Bagotville Barrage, is located at the confluence of the drainage network to the south. The barrage is fitted with a series of floodgates providing a discharge point to the Richmond River (Figure 26). The majority of this zone is within the LCC local government area with the eastern portion lies within the BSC local government area.

The Tuckean Swamp is extensively drained and dominant land uses are sugar cane and cattle grazing. Upper catchment land uses are more varied including significant areas of macadamia orchards and mixed horticulture. Tuckean Nature Reserve occupies a large area (1,300 acres) of this zone.

There are significant management issues in the Tuckean that affect the health of the Richmond River estuary downstream. The eastern and north-eastern regions of the Tuckean backswamp contain large areas of actual ASS and potential ASS deposits. The area was identified by Tulau (1999) in ASS hotspot mapping and is one of the largest areas of ASS in NSW (WBM, 2006). Peat fire risk is also heightened within drained and/or ASS areas, where the peat dries out and vegetation dies off and becomes fuel. Peat fires are known to occur in the Tuckean and can last for several months, only to be extinguished by flooding. In addition, the Tuckean has one of the highest recorded concentrations of monosulfidic black ooze (MBO) reported in the world (Bush *et al*., 2004). The backswamp areas of the Tuckean have been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010).

Plate 11: Acid scald in the Tuckean

Source: M. Wood

Despite major issues with ASS and blackwater, the Tuckean also contains areas of high value vegetation. High Conservation Vegetation including Endangered Ecological Communities exist along the eastern side of this zone including Swamp Sclerophyll Forest on Coastal Floodplains, Sub-tropical Coastal Floodplain Forest, Swamp Oak Forest, and Freshwater Wetlands on Coastal Floodplains. Important but isolated small remnants of vegetation remain among sugarcane land in the south of the zone and their protection is important to conserve biodiversity values of this area.

The riparian survey undertaken by Australian Wetlands (2010) for the Tuckean zone covered the Tuckean Broadwater between Bagotville Barrage and the confluence with the main river channel. The riparian vegetation was often greater than 50m wide with a high native cover in the canopy (60% - 100%). The riparian vegetation along the main channel near Broadwater Road was highly diverse but narrow and threatened by climbing weeds in places. The riparian vegetation included remnant rainforest species. Several water weeds, transported to the site by flood waters, were evident near the bank.

The Tuckean Broadwater is steadily infilling and narrowing due to the constriction of the Bagotville Barrage. Mangroves have colonised mudflats and all sea grasses have gone. The Bagotville Barrage has also created a separation of vegetation with freshwater *Melaleuca quinquenervia* upstream and Mangroves downstream. Some colonising by mangroves has been recorded since the implementation of tidal flushing in 2002. Of note for management is the encroachment of *Melaleuca quinquenervia* in the backswamp, which is occurring in response to altered hydrology and fire and is impacting the natural biodiversity of the area.

Plate 12: Westerly view of Tuckean Swamp showing drains traversing wetlands in foreground

Source: J. Baldwin, 1997

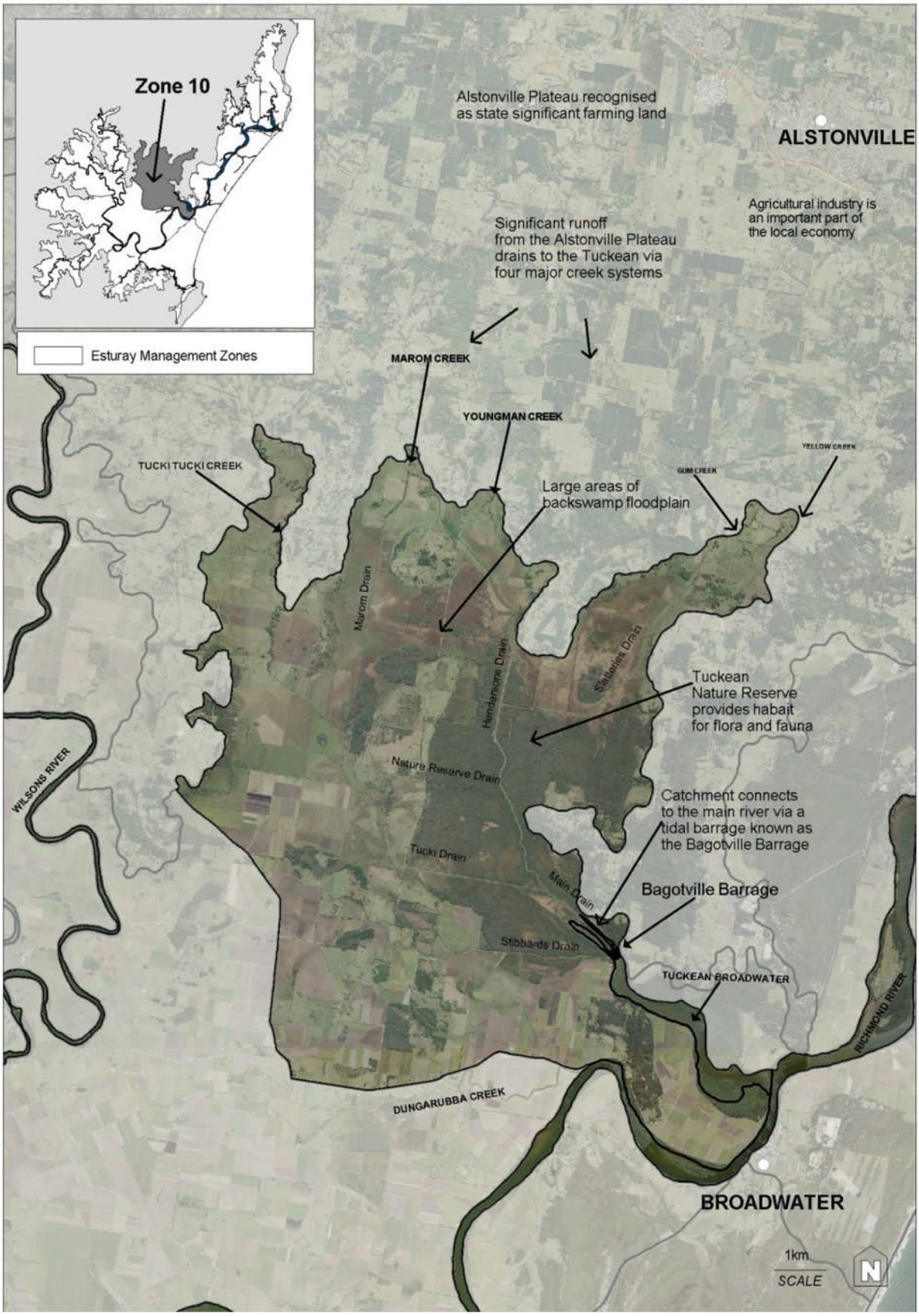


Figure 26 – Zone 10 Tuckean: Major Features

Source: aerial photography provided by RRCC

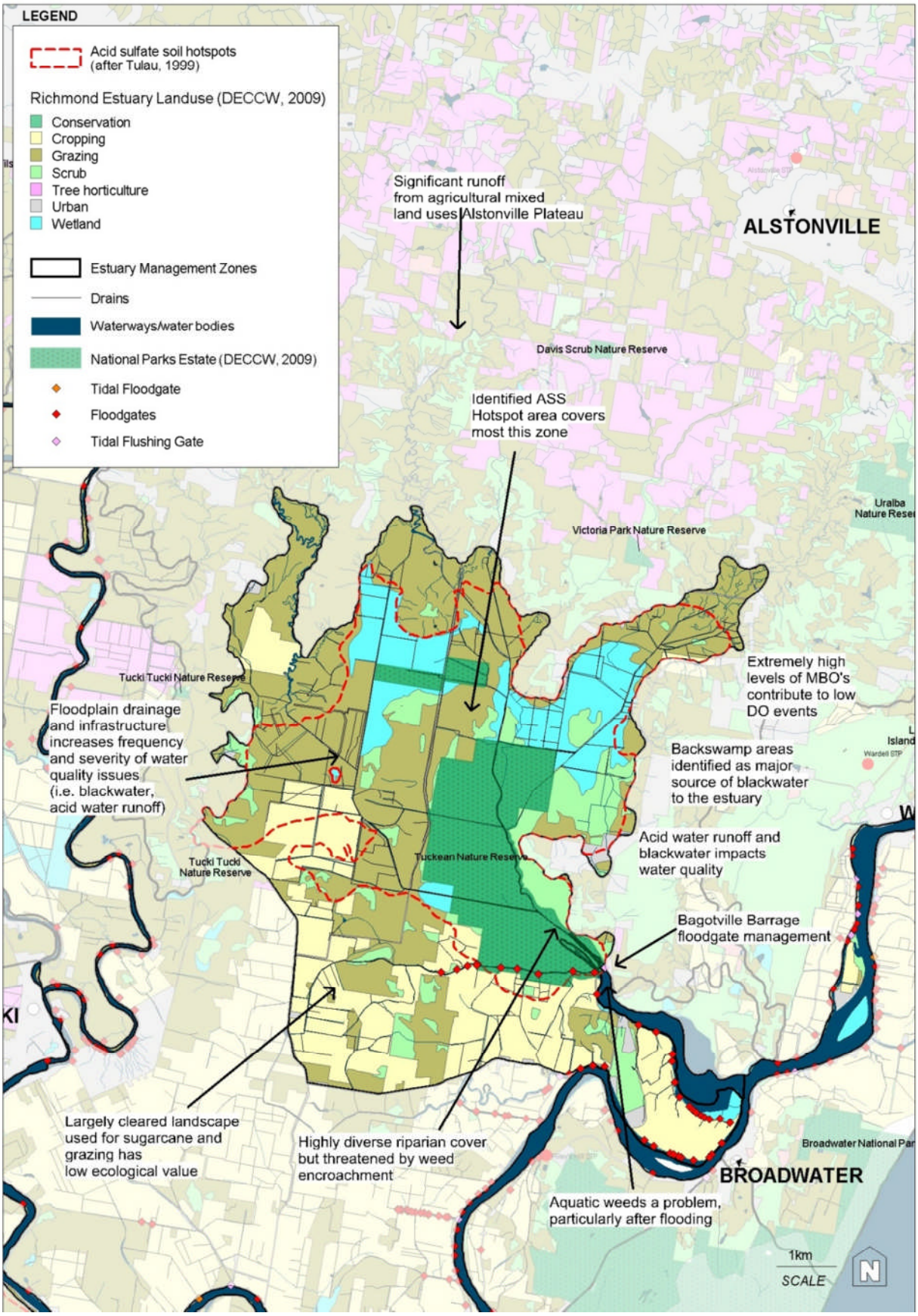


Figure 27 - Zone 10 Tuckean: Management Issues

3.12 Zone 11 – Lower Bungawalbin

The Lower Bungawalbin management zone encompasses both the lower alluvial floodplain reaches of Bungawalbin Creek and the backswamp areas of Sandy Creek. This zone lies within the RVC local government area.

In their natural state, the Kookami and Bora Codrington Swamps, along with the Richmond River paleochannel region to the east of Kookami, constituted an extensive open wetland swamp system with large areas of semi-permanent water bodies (Owers, 2005). Draining of the swamp system began in the late 1800s resulting in widespread shifts away from wetland vegetation and oxidation of ASS (WBM, 2006). Backswamp areas and Sandy Creek have active ASS areas creating considerable acid runoff and have been identified as ASS hotspots (refer Section 7.5.1). The backswamp areas of Bungawalbin and Sandy Creek have also been identified as one of the three major sources of blackwater to the estuary (Wong *et al*., 2010). The Bungawalbin sub catchment is one of the highest contributors of freshwater to the Richmond estuary and as such has a major influence on water quality in the main estuary.

The lower reaches of Bungawalbin Creek feature a meandering tidal channel through the alluvial floodplain with numerous oxbow cutoffs. The riparian zone, along the lower reaches of the creek, is generally narrow and fragmented, while the upper reaches feature extensive tracts of overhanging riparian vegetation.

The Sandy Creek channel becomes shallower as it traverses the Kookami Swamp, where it is augmented by constructed drainage. The Bora Codrington Swamp lies to the south of Kookami, and is drained by a network of constructed drainage at its confluence with Sandy Creek. Riparian vegetation is fragmented along much of Sandy Creek and is largely absent from drains in Kookami, Haughwoods and Bora Codrington Swamp.

All publicly owned floodgates are actively managed. Rehabilitation works have been implemented at Mynumai Lagoon, Bora Creek and Seelim Creek. Drain infilling and groundwater management have been implemented at Haughwoods Canal and Bora Codrington.

Plate 13: Pelicans on a flooded paddock Ellangowan Road, Bungawalbin

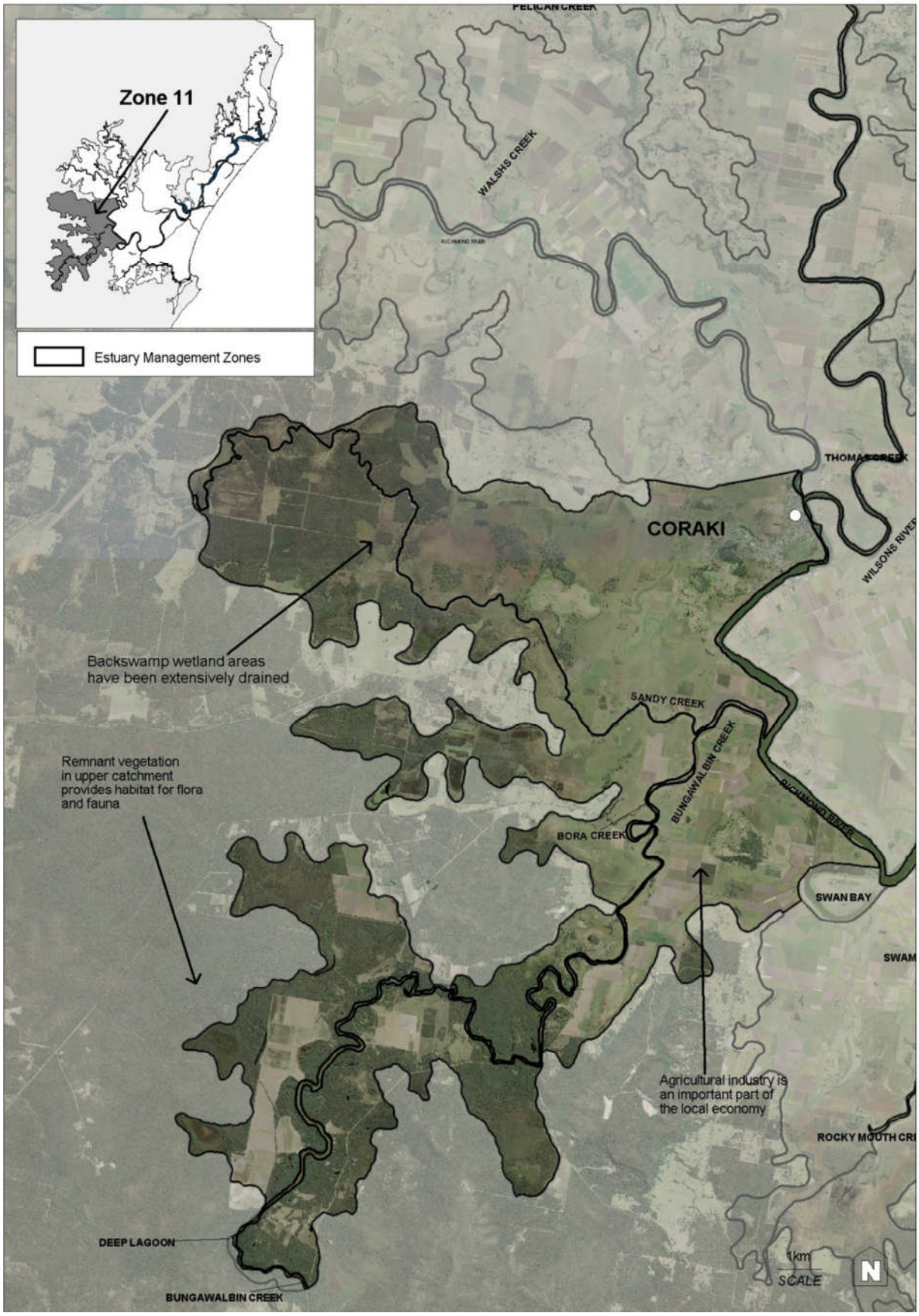


Figure 28 – Zone 11 Lower Bungawalbin: Major Features

Source: aerial photography provided by RRCC

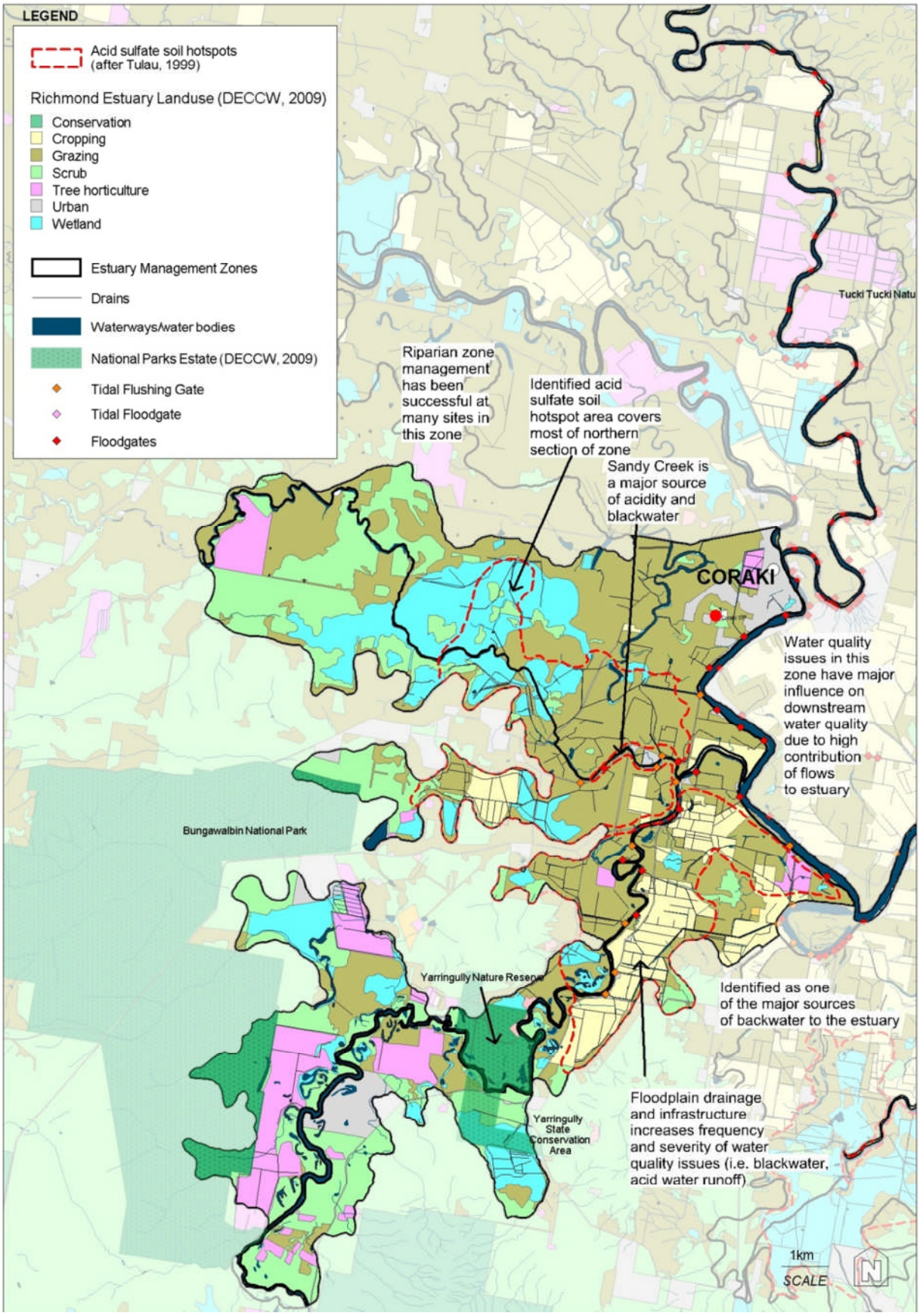


Figure 29 - Zone 11 Lower Bungawalbin: Management Issues

3.13 Zone 12 – Upper Richmond / Wilsons River

The Upper Richmond / Wilsons River management zone encompasses the alluvial floodplains of the Richmond and Wilsons River tidal arms above Coraki. This zone is within the boundaries of both LCC and RVC (Figure 30).

The zone has a large floodplain and catchment area, mainly cleared for agriculture (grazing and cropping). There are also substantial areas of agriculture in the upper catchment areas that contribute to the overall sediment and nutrient load of the estuary. The EPS (WBM, 2006) reported that the Wilsons River catchment was expected to generate the highest phosphorus loads in the Richmond catchment (WBM, 2006). Major urban areas of Lismore and Casino lie upstream of this zone, and the estuary is subject to wastewater discharges and urban runoff from these sources. Much of the area also contains septic tanks and rural residential subdivision is a growing pressure, increasing the septic load in the area. Rous Water has a licence to extract water for town water supply from the tidal pool upstream of Lismore (NSW Office of Water, 2009).

Small areas of remnant vegetation remain within Tucki Tucki Nature Reserve, Ruthven Recreation Reserve and Travelling Stock Reserve. The Pelican Creek Management Plan was completed in 2006 and contains a suite of management actions recommended to improve the ecological values of Pelican Creek. Restoration of Pelican Creek riparian sites was carried out in 2007-2009. Wilsons River is mainly cleared of riparian vegetation with some remnant areas. Bank erosion and slumping was recorded by Australian Wetlands (2010) and attributed mainly to lack of vegetation cover.

Inundation of the upper Wilsons floodplain during floods is considered to be a large contributor of blackwater to the Richmond River Estuary (Eyre *et al.*, 2006).

Plate 14: A typical area of floodplain in the lower Pelican Creek Catchment

Source: LCC, 2006

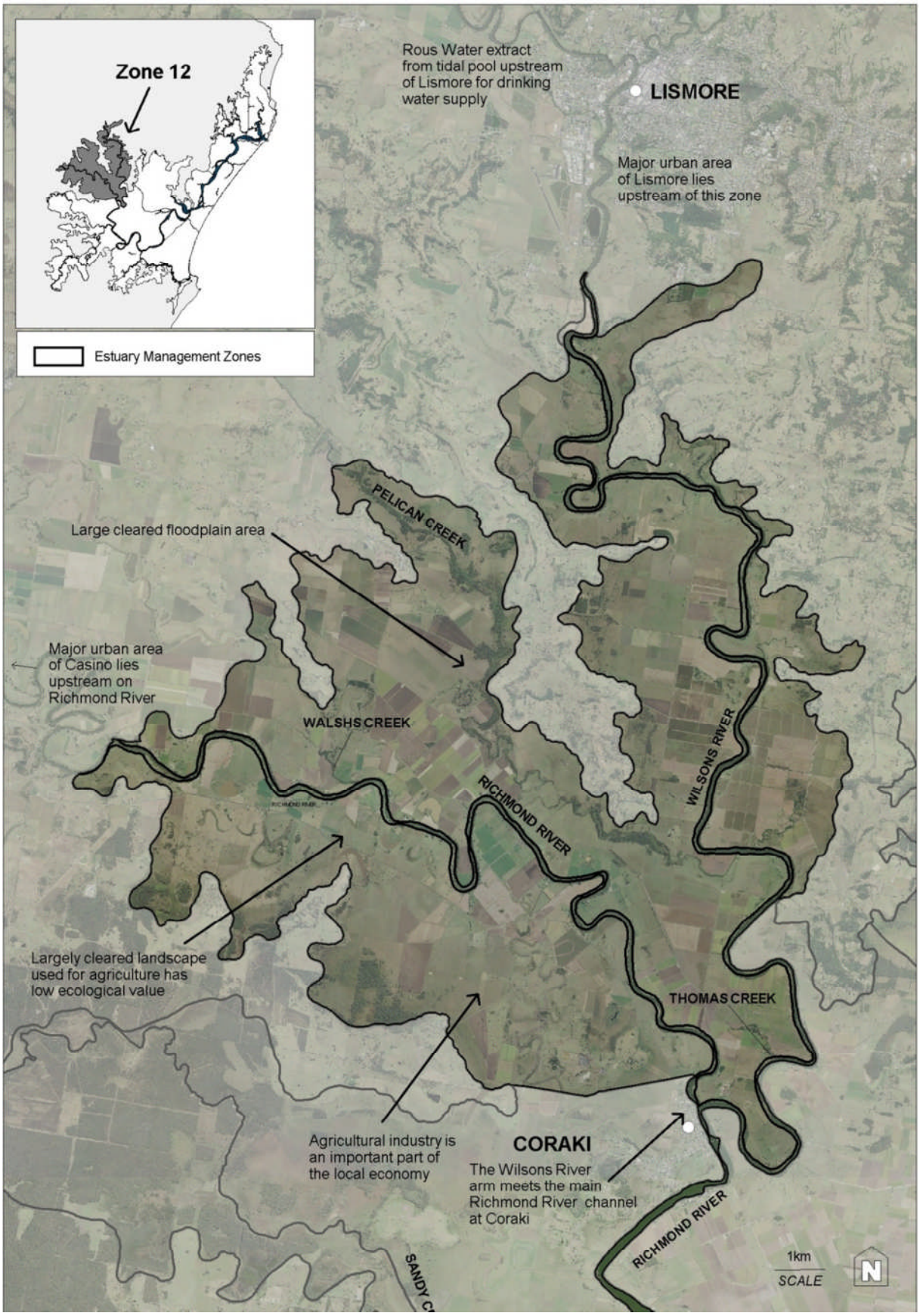


Figure 30 – Zone 12 Upper Richmond / Wilsons River: Major Features

Source: digital imagery provided by RRCC

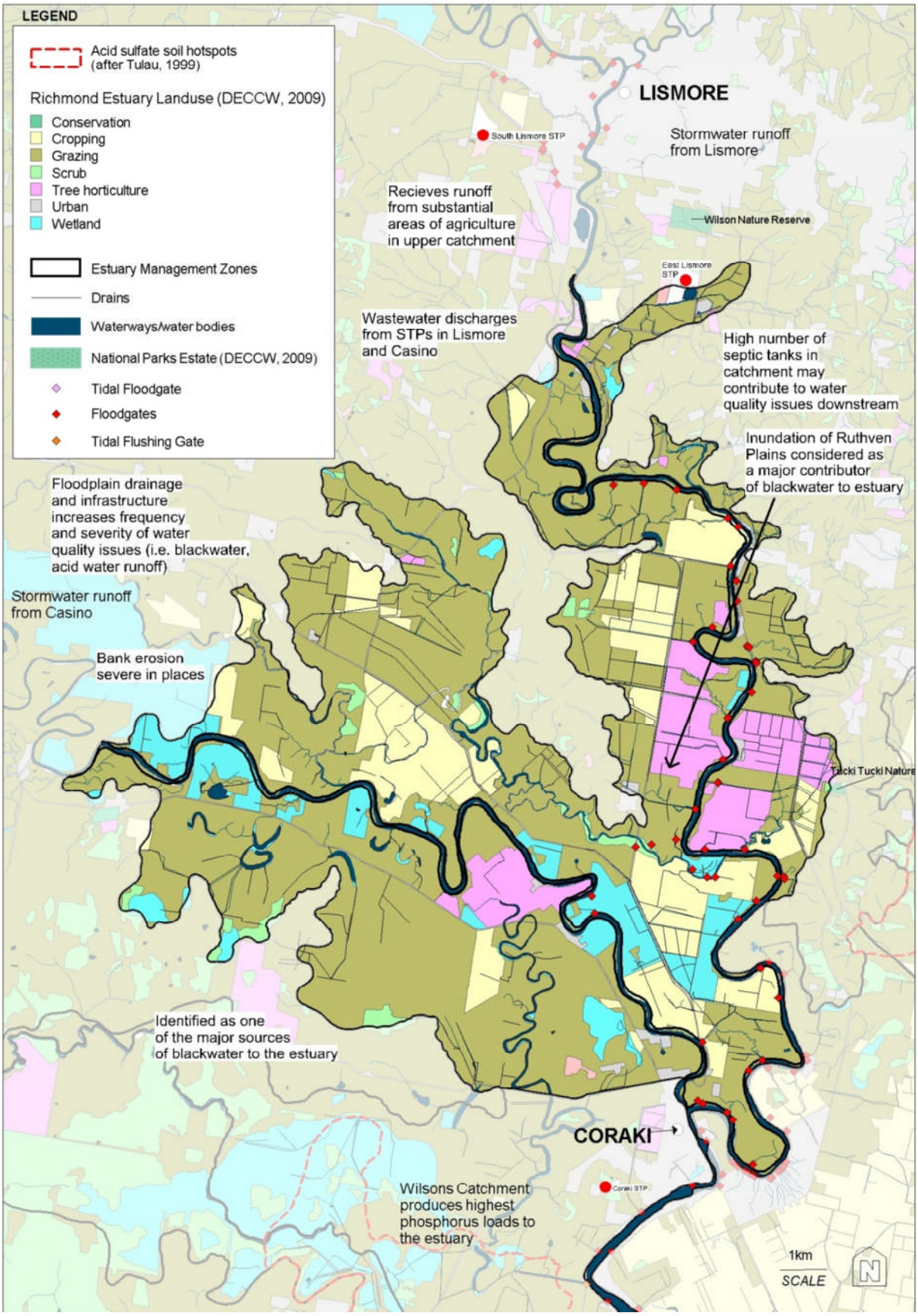
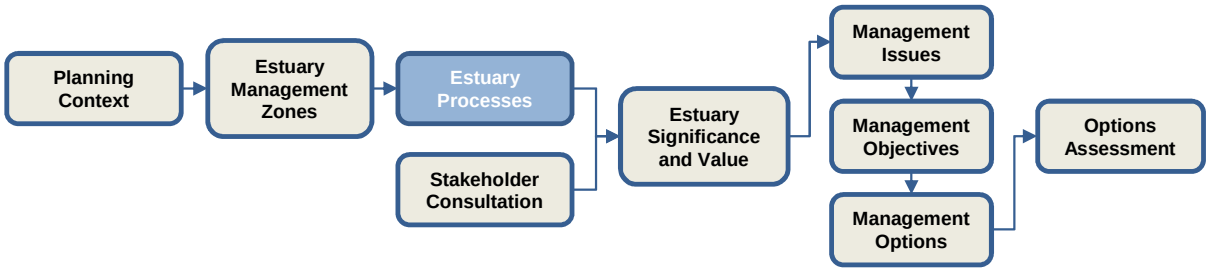


Figure 31 - Zone 12 Upper Richmond / Wilsons: Management Issues

4. ESTUARY PROCESSES



This Section provides an update of recent technical information related to the management of the Richmond River Estuary, since the completion of the Estuary Processes Study (WBM, 2006; ABER, 2007; ABER, 2008).

Further discussion of estuary issues is provided in Section 7.

4.1 Estuary Processes Study

The Richmond River Estuary Processes Study (EPS - WBM, 2006) and technical review (ABER, 2007) provide scientific understanding of the key processes controlling ecological patterns within the estuary and identify the issues and knowledge gaps to be considered in the development of the Draft EMS and Draft CZMP. These documents provide an overview of the key physical, chemical and biological processes operating within the estuary and how these processes interact and influence each other. They provide a description of the processes involved for each issue and the flow of impacts through the system. The combination of the two documents provides a good scientific basis on which to build management strategies for the Richmond River. The key findings of these documents are discussed in this Draft EMS.

4.2 Recent Research

Since the completion of the EPS (WBM, 2006), a number of subsequent studies have been undertaken in the estuary. The following section provides a review of relevant recent studies currently available that have specific relevance to the development of the Draft EMS and Draft CZMP, to update the current understanding and emerging issues. Please note there are also a number of studies currently underway or in planning stages that may offer further insights into management issues. When available, this work should be utilised to optimise any recommendations of the Draft EMS and Draft CZMP. Understanding the complexity and range of issues and pressures on the estuary will be important for developing options for sustainable management.

4.2.1 Water Quality and Fish Kills

Since completion of the EPS (WBM, 2006), further study has been undertaken in the Richmond catchment and waterways to provide more information on fish kill events occurring in the Richmond following floods and particularly to provide details on the sources of poor water quality, blackwater and potential remediation options.

Blackwater is a term used to describe floodwaters with very low oxygen content and high organic load, emanating from the floodplain's backswamp areas. The organic matter suspended in the water column turns the floodwaters 'black' and gives off an unpleasant odour. Blackwater has been identified as the primary contributor to fish mortality events on the lower Richmond (Moore, 2006; Eyre *et al*., 2006; Wong et. al, 2010). Wong *et al*. (2010) recently completed a large-scale study of post-flood water quality in the Richmond that identified the backswamp areas of the Tuckean, Rocky Mouth Creek and Bungawalbin Creek systems as the most significant sources of blackwater. This correlates with results of a water quality data review conducted by ABER (2008), which identified the Tuckean, Rocky Mouth Creek, Bungawalbin, and Kilgin/Buckendoon areas as high risk for water quality impacts, primarily associated with low dissolved oxygen. These areas are all located in the mid-estuary, which is in contrast to previous concerns that deoxygenated waters were coming from the upper estuary.

Eyre *et al* (2006) tested the deoxygenation potential of various types of floodplain vegetation. Slashed pasture was found to be the most oxygen demanding, followed by harvested tea tree and cane trash. However, ten hours after inundation the oxygen consumption rates of slashed pasture and tea tree cuttings had decreased to a rate less than the harvested cane trash. They estimated that the lower floodplain (an area of approximately 31,000ha based on the February 2001 flood event) has the capacity to deoxygenate all stored floodwaters within 3 to 4 days.

Plate 15: Left - The 2008 Richmond River fish kill. Right: Clean-up after fish kill

Source: M. Riches, P. Dwyer

Recent studies have also confirmed the role of the existing floodplain drainage systems in exacerbating the problem by acting as a conduit for deoxygenated waters to discharge to the main river channel (Wong *et al*., 2010; Eyre *et al*, 2006). As floodwaters begin to recede in the main river channel, drains convey deoxygenated water on the floodplain at high velocity to the main river resulting in large areas of the estuary being completely deoxygenated with the resulting increased magnitude and duration of poor water quality in the estuary.

It is well established that temperature is one of the major factors influencing deoxygenation, with higher temperatures leading to faster rates of decomposition and faster consumption of oxygen from the water. Higher temperature water also holds less dissolved oxygen than cooler water. Temperature was the main differentiating factor in comparing the January 2008 flood, and the May 2009 flood in the Richmond River (Wong *et al*., 2010). Wong *et al*.(2010) attributed the higher temperatures experienced in January 2008 as a major factor in the subsequent fish kill, reasoning that no fish kill occurred following the May 2009 flood when temperatures were approximately 10 degrees cooler.

Management recommendations coming out of recent studies generally correlate with those discussed in the EPS (WBM, 2006) and involve changes in landscape management and farming practices. The emphasis of the recent studies is on changes in pasture management to more inundation tolerant species, and changes in harvest and trash management, such as removing slashed pasture from flood-prone areas (Eyre *et al*., 2006; Moore, 2006). While harvest management changes were one of the recommendations coming out of Eyre et al. (2006), the removal of slashed pasture is impractical on a number of levels and undesirable for farmers who wish to return nutrients to the soil. It is not considered to be a feasible solution in blackwater management. Recommendations for changes to floodplain management were to retain deoxygenated floodwaters in low lying areas for longer, to allow oxygen consumption processes to be completed before releasing this water back to the estuary (Eyre *et al*., 2006). Walsh *et al*. (2010) recently conducted an assessment of identified blackwater mitigation options for the Richmond River Estuary and concluded that there were a range of options available

likely to have positive benefits for the estuary, but many factors required further investigation to effectively plan for implementation. Options for management of blackwater are discussed further in Section 7.5.3.

Results of a water quality review by ABER (2008) for each of the major floodplain sub-catchments were synthesised into a risk assessment to prioritise sub-catchments in terms of water quality impacts. The assessment is qualitative, providing a low, medium or high rating for acidity, dissolved oxygen, turbidity, nutrients and organic matter (OM) under different flow conditions. The risk assessment matrix (Table 3) highlights five priority sub-catchments for management of water quality issues: Tuckean, Bungawalbin/Sandy Creek, Kilgin/Buckendoon and Rocky Mouth Creek. Specific water quality issues are discussed further in Section 7.5.1.

Table 3: Risk assessment matrix for in-stream water quality and potential downstream impacts on the estuary (Red=High, Yellow=Medium, Green=Low).

		In stream						Downstream					
Subcatchment	**flow**	salinity	pH	DO	Turb	Nutrients	Organic matter	export	pH	DO	Turb	Nutrients	Organic matter
Tuckean	high	F	m	h	h	h*	h*	h*	m	h	h	h*	h*
	median	F	h	m	l	m*	m*	m*	h	m	l	m*	m*
	low	M	h	m	l	l*	l*	l*	l	l	l	l*	l*
Bungawalbyn / Sandy Creek	high	F	l	h	h	h*	h*	h*	m	h	h	h*	h*
	median	F	m	m	h	m*	h*	m*	l	m	m	l*	l*
	low	M	m	l	l	l*	l*	l*	l	l	l	l*	l*
Kigin / Buckendoon	high	F	l	h	h	m*	h*	m*	m	h	h	h*	h*
	median	F	h	m	m	m*	m*	l*	l	l	l	l*	l*
	low	M	m	h	h	h*	h*	l*	l	l	l	l*	l*
Rockymouth Creek	high	F	m	h	m	m*	h*	m*	m	h	h	m*	h*
	median	F	h	h	l	m*	m*	l*	l	m	l	l*	l*
	low	M	m	m	l	l*	l*	l*	l	l	l	l*	l*
Emigrant/Maguries	high	F	l	l	m*	m	m*	m*	l	m	m	m	m*
	median	F	l	m	m*	m	m*	m*	l	l	l	m*	m*
	low	M	l	h	l*	m	h*	l*	l	l	l	m*	l*
North Creek	high	F	l	m	m	h	m*	m*	l	m	m	m	m*
	median	F	m	l	l	m	m*	l*	l	l	l	l*	l*
	low	M	l	m	l	m	h*	l*	l	l	l	l*	l*
Empire Vale	high	F	l	l	m*	m	m*	l*	l	l	l	l*	l*
	median	F	l	m	m*	l	m*	l*	l	l	l	l*	m*
	low	M	l	h	l*	l	h*	l*	l	l	l	l*	l*

F=Freshwater , M=Mesohaline (between freshwater and seawater)

Source ABER, 2008

4.2.2 Richmond River Flood Study 2010

The Richmond River Flood Mapping Study was commission by RRCC and Richmond Valley Council (RVC) in 2008. The study (BMT WBM, 2010) provides an understanding of flood behaviour across the study area. The key outputs of the study were calibrated hydrologic and hydraulic models covering the entire Richmond River catchment, and detailed flood mapping of historical and design flood events, in particular flood levels and hazards. While playing a key role in asset protection and emergency planning, the models developed as part of this project can also be used and further developed for a range of future applications, in particular to aid floodplain management decisions.

The Digital Elevation Model (DEM) created as part of the flood study highlighted that some parts of the floodplain are at extremely low elevation. Areas such as Rocky Mouth Creek, parts of the Tuckean Swamp, Kilgen/Buckendoon, Emigrant/Maguires Creek, North Creek/Newrybar and South Ballina are at or below sea level (refer to Figure 35, Section 7.5.1) confirming the practical difficulties with maintaining drainage from these areas.

4.2.3 Riparian Zone and Geomorphological Assessment

The Estuary Management Committee commissioned a number of data collection and/or review exercises for the study area including an assessment of riparian vegetation, geomorphology, and water quality (Australian Wetlands, 2010). Details of the results of the study including raw data from on-ground assessments are provided in Appendix 2. The following Section is a brief description of this work and conclusions. The relevant results for each Management Zone are referred to in more detail in the Management Zone descriptions (Section 3) and Issues discussion (Section 7).

Riparian Assessment

Australian Wetlands carried out an assessment of riparian vegetation for the study area combining a broad desktop study of aerial photography with an on-ground Rapid Assessment Method (RAM) to provide an overview of riparian vegetation based on management zones. The parameters recorded were:

- Longitudinal connectivity (Aerial Photograph Interpretation, API);
- Width of riparian vegetation (API);
- Native vegetation cover;
- Site weed control issues; and
- Habitat quality assessment.

These data may be useful in follow up surveys following any rehabilitation works. The main conclusion of the study was that the riparian zone bordering the Richmond River estuary and tributaries was generally devoid of vegetation for much of the area. Where riparian vegetation was present it was generally degraded, with only a few examples of intact riparian vegetation in good condition. The width of the bank vegetation was often less than five metres and few native trees remained. Serious weed invasion was occurring on the banks as there was limited natural vegetation to inhibit the growth of weeds. The major weeds were Camphor Laurel and Cockspur Coral Tree. In some places, particularly North Creek and the lower Estuary, there was some remnant vegetation with good native canopy and mid-storey trees. The understorey was largely dominated by pasture grasses leaving little opportunity for seedling regeneration and nutrient interception, suggesting that the current vegetation is not providing viable riparian function.

Geomorphological Assessment

The geomorphological assessment involved observations made during a catchment tour together with a literature review and the results of the on-ground site assessment. Data gathered were used to provide a geomorphic status assessment for each management zone. Scores were assigned to each site based on various assessment methods for the following categories:

- Stability;
- Condition; and
- Recovery potential.

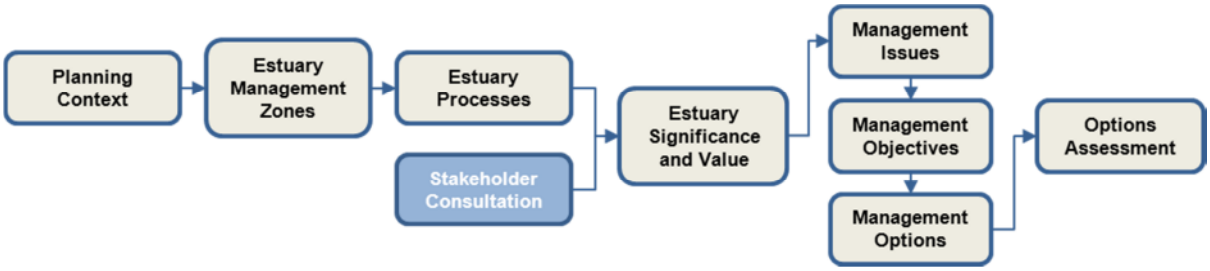
The issues occurring within each of the twelve management zones are primarily a direct consequence of anthropogenic activity which began with permanent European settlement of the Richmond River Basin from around 1842. Extensive land clearance, initially for the timber industry, but also to facilitate the establishment of broad scale farm based agricultural enterprises has set the scene for an altered landscape which is more susceptible to fluvial erosion processes in this high rainfall region.

The cumulative effects of a largely cleared landscape are most evident along the steeper slopes of upper catchments and the upper to mid floodplain where erosion scarps and bank slumping are common in areas no longer bordered by natural riparian vegetation.

Drainage modification for farming (particularly sugar cane), roads and flood mitigation measures have impacted the natural flow regimes. In these areas, there is no longer the capacity for streams to establish natural meanders in response to landscape gradients and natural rates of flow. Consequently, drainage patterns are established to suit farming practices and in addition to hydrologic changes, promote erosion of fallowed soil during high rainfall events, and facilitate direct transport to the main river system.

The major geomorphic-related management issues for the Richmond River Floodplain were sheet and rill erosion, drainage modification for agriculture, water course obstructions, and a lack of suitable riparian vegetation as the common elements across all Management Zones.

5. STAKEHOLDER CONSULTATION



This Section summarises the consultation activities undertaken as part of the Estuary Management Program.

Various forms of stakeholder consultation have been conducted throughout the Estuary/Coastal Zone Management Planning Process. The Richmond River Estuary Management Committee was formed in 2002 to oversee the process from data compilation study and estuary processes study to development of the Draft EMS and Draft CZMP (refer Section 2.2.4). The Floodplain Management Committee was formed in 2000 by RRCC. Its role is to contribute to floodplain management and environmental improvement. The Richmond River Estuary Technical Team was established to oversee the development of the studies and management plans.

The Richmond River EPS (WBM, 2006) included a community consultation phase via a community survey, although there were limited responses at that time. Australian Wetlands conducted a wide range of stakeholder engagement activities on behalf of the Estuary Management Committee in 2007/08.

The Draft EMS and Draft CZMP were placed on public exhibition between 14 March and 6 May 2011. A public meeting was held and submissions were invited.

Feedback from stakeholders has been considered in the preparation of the Draft CZMP for the Richmond River Estuary including definition of values (Section 6).

Appendix 3 provides further detail on the consultation activities.

5.1 Community Consultation

5.1.1 Estuary Processes Study, 2006

During the preparation of the EPS (WBM, 2006), community consultation activities were initiated through the Estuary Management Committee to obtain information on:

- The current types and locations of estuarine use;
- The values of the estuary; and
- Estuarine issues that require management.

Consultation techniques included site inspections with Committee Members and a Discussion Paper, which was distributed to members of the Estuary Management Committee in order to obtain comment on specific items. A copy of the Discussion Paper is included in Appendix 3.

5.1.2 Draft CZMP preparation 2007/08

Consultation activities were conducted by Australian Wetlands during 2007/08 with particular groups representing specific interests in the estuary, community focus groups made up of interested individuals as well as canvassing of the broader community through local radio, newspapers and information stalls. The groups involved in community consultation were:

- Estuary Management Committee;
- Floodplain Committee;
- Northern Rivers CMA;
- Local Government (BSC, RVC and LCC);
- Indigenous Groups (Bundjalung Elders, Ngulingah Local Aboriginal Land Council, other key Aboriginal stakeholders);
- Community Focus Groups (lower catchment and upper catchment groups);
- General Community communication (ABC radio, newspaper, information stalls at public events); and
- Far North Coast Weeds;

The local community was surveyed for their opinions on the estuary, its condition, issues and possible means to improve the condition. Their values were recorded and a list of estuary values developed. Healthy water quality was the highest priority over all. The feeling from the community is that if the water quality was good then ecologically, economically, socially and aesthetically the river would benefit. Other issues raised included a need to address governance issues and identifying who takes responsibility for implementing and funding the actions. There was also a view from the community that the local, state and federal departments relevant to natural resource management are fragmented and do not interact efficiently. Results of the consultation activities are included in Appendix 3.

5.1.3 Public Display of Draft EMS and Draft CZMP, 2011

The Draft EMS and Draft CZMP were placed on public exhibition between 14 March and 6 May 2011 to provide the community with the opportunity to assess what is proposed for the estuary, the actions and implications of the proposed strategies and to provide feedback on the management plan. An introduction to the project, the Draft documents and a Summary Document were available from the RRCC website with hard copies available for review at Council administration offices in Lismore, Ballina, Casino and Evans Head. Posters advertising the exhibition period were on display at Council

offices and advertisements were placed in local media. A public meeting was held on 28 March 2011 in Ballina to provide information on the draft documents. Submissions on the draft documents were reviewed and considered in the finalisation of the Draft EMS and Draft CZMP.

5.2 Indigenous Community Consultation

Consultation activities with Indigenous representatives identified a number of information gaps and recurring issues including:

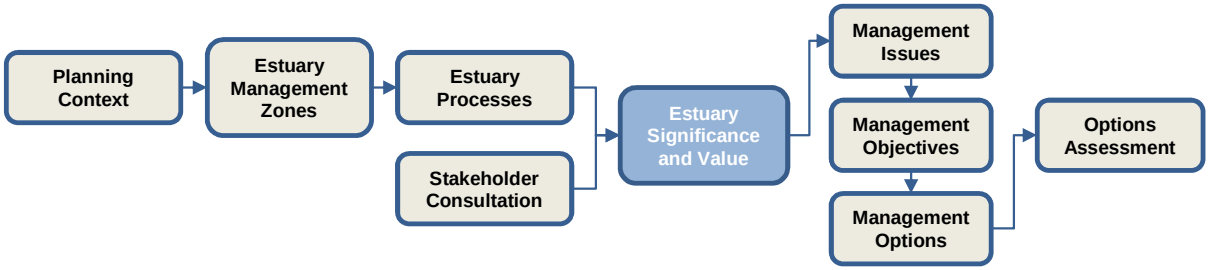
- Satisfactory resolution of Native Titles and Claims – there are four Native Title Claims covering approximately 90% of the study area currently being assessed (claims apply to land other than freehold land such as Crown Land and leasehold lands);
- Lack of community understanding regarding Indigenous Fishing Rights;
- Cultural Heritage Studies are incomplete. All levels of Government maintain registers of levels of protection under current legislation, ongoing studies aim to improve the Aboriginal Heritage listings within the Richmond River;
- Timely adoption of cultural heritage sites and artefacts in appropriate registers to ensure long term preservation; and
- Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works occurring around the estuary).

The resolution of the above issues will help engage the Aboriginal community and aid further cooperation. Through indigenous engagement, a historical and cultural perspective on the use and health of the estuary can be obtained.

5.3 Council and Agency Stakeholder Consultation

The Richmond River Estuary Technical Team consists of key personnel from the local government areas within the estuary and agency stakeholders (refer Section 2.2.4). The Technical Team met on a regular basis to discuss on-going estuary management projects and provide feedback on the development of the Draft EMS and Draft CZMP (Volume 1).

6. ESTUARY SIGNIFICANCE AND VALUES



The significance and value of the estuary have been derived from the scientific understanding of the estuary (Section 4) and the outcomes of the stakeholder consultation (Section 5).

6.1 Estuary Significance

The Richmond River is one of the major coastal drainage systems in northern NSW with a catchment area of approximately 6,850 km^2. The Richmond River is unique, with a large flood plain (approximately 1,000 km^2) relative to catchment area and a small water surface area (19km^2) (WBM 2006).

Many significant townships exist in the study area, with most located on the banks of the Richmond River estuary system including Lismore on the Wilsons River, Casino on the upper Richmond River, Coraki (near the meeting of the Wilsons and Richmond Rivers), Woodburn, Wardell, and Ballina on the lower portions of the Richmond River. There is increasing population pressure with the major urban centres targeted as expanding regional centres and the close proximity to south-east Queensland and resulting tourism and development pressures.

Major changes since European settlement are (ABER, 2007):

- 70% of the land around the estuary has been cleared. There is currently little native forest remaining, with most large remnants restricted to steep slopes or heathlands. Very little remnant vegetation occurs on the floodplain areas adjacent to the estuary;
- Most of the cleared and drained lands are utilised for cattle grazing or sugar cane production;
- The hydrology of the floodplain has been significantly modified. The naturally swampy floodplain has been extensively drained via complex networks of drainage channels and floodgates;
- While urban areas account for only 2% of the land around the Richmond River estuary, the urban growth rate is rapidly increasing. The population of Lismore City, Ballina and Richmond Valley Shires now exceeds 100,000 and future urban expansion will be necessary to accommodate projected increases in population;
- Much of the lower estuary, including the entrance, has been rock lined to stabilise shifting channels and maintain navigation.

Approximately 34,000 ha of floodplain within the Richmond River catchment are potentially underlain by high risk ASS, with another 34,000 ha having low risk ASS (WBM, 2006). The natural characteristics of the Richmond River catchment and floodplain, such as presence of potential ASS, large floodplain to catchment ratio and poor flushing characteristics are all elements that interact with and exacerbate the impact of human pressures. Together these factors contribute to the degradation of the waterway and occurrence of undesirable events such as poor water quality episodes, fish kills and oyster declines, which impact on commercial, social, environmental and cultural values.

6.1.1 National Significance

The catchment of the study area occurs in the McPherson-Macleay Overlap area, which is an area of extremely high biodiversity, resulting from the wide range of soil types, climate and topography across the region. This overlap area has the third highest level of biodiversity in Australia (Richmond Regional Vegetation Committee, 2002).

Within the Richmond River estuary, the Bundjalung National Park and the Broadwater wetlands are listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001). The estuarine wetlands of the Richmond River catchment provide habitat for a large number of migratory waders including federally listed threatened species.

The estuary is a significant contributor to the Australian east coast fishery through a range of mechanisms including direct contribution to catches, provision of nursery habitats, spawning stock and nutrients for offshore fisheries.

6.1.2 State Significance

The Richmond River catchment includes large areas of National Park (Broadwater, Bundjalung and Bungawalbin National Parks) and Nature Reserves (Richmond River, Yarringully, Ballina and Tuckean Nature Reserves).

The wetlands of the Richmond River catchment provide habitat for one of the widest range of wetland dependant threatened species in NSW. The high-energy nature of the NSW north coast means there are no intertidal wetlands between estuaries, so there is a natural fragmentation of these habitats on a regional scale, giving weight to the conservation significance of habitats in each estuary (ABER, 2007).

The Richmond River is the seventh largest (by surface area) estuary in NSW, with the fifth largest finfish catch in the region (ABER, 2007). In addition to the high fisheries/productivity value of the estuary, the estuary supports species, habitats and communities of conservation concern. These include:

- Rare and threatened communities, as defined under the Threated Species Conservation Act, 1995 (refer WBM, 2006), namely:
    - Coastal Saltmarsh;
    - Swamp Oak Floodplain Forest;
    - Swamp Sclerophyll Forest On Coastal Floodplains;
    - Freshwater Wetlands On Coastal Floodplains;
    - Littoral Rainforest;
    - Lowland Rainforest on Floodplains; and
    - Ripple-leaf Muttonwood (*Rapanea* species A Richmond River).
- Wetlands of conservation significance: SEPP 14 wetlands (4964 ha) and Zone 7(a) Environmental Protection (Wetlands) or E2 (Environmental Conservation) under the new LEP instrument;
- SEPP 26 Littoral rainforest (47.1 ha); and
- Oxleyan Pygmy Perch – Evans Head (Fisheries Management Act 1994).

6.1.3 Regional Significance

Agriculture is a major driver of the local economy, employing approximately 10% of the working population in the North Coast Region (includes Byron, Ballina, Richmond Valley, Lismore City and Kyogle Shires). Local forms of agriculture include cattle grazing, sugar cane cropping, and horticulture. The Alstonville Plateau area has been designated state significant farmland as part of the Northern Rivers Farmland Protection Project. Areas designated as regionally significant farmland include parts of North Creek, Empire Vale and Woodburn (DPI, 2005).

As well as the agriculture industry, the Richmond River estuary has regionally important commercial and recreational fisheries. Commercial fishers target a wide range of species although four species represent approximately 87% of the total catch (1997-2004): Mullet (51% of catch), school prawn (27.5% of catch), Long-finned eel (4.8% of total catch), and Luderick (3.7% of total catch). The Sydney

rock oyster is grown and harvested within the Richmond River. The farm gate oyster sales of the Richmond River estuary oyster industry are estimated to be around $200,000/year, which is about 0.5% of the State industry income (ABER, 2007).

Tourism and recreation are also major economic drivers for the North Coast Region. Outdoor recreation and sports (e.g. swimming, fishing, boating) are popular activities, particularly in the lower estuary near Ballina. The value of tourism to the North Coast Region is estimated at $646 million, and supports some 6,000 jobs. Tourism has been identified as a priority industry for the North Coast Region.

6.2 Estuary Values

The Richmond River estuary is highly valued by the community and is a focal point for local commerce, tourism and recreation. The estuary with its associated wetlands and waterways support a rich biodiversity and a range of important environmental functions including ecosystem services (habitat, breeding areas and food sources) as well as local industry. Despite these recognised values, the system is under pressure from past and existing development, catchment disturbance and hydrological modification, land use management and large-scale vegetation changes. Looking forward, the estuary faces continued pressure from future development within the catchment.

The main aim of the coastal zone management planning process is to increase resilience within the estuary and to protect and enhance the key values and it is therefore an essential step in the EMS to clearly document these values. Review of previous documentation was undertaken in order to identify and assess the established values for the estuary (WBM, 2006 and ABER, 2007). The reported outcomes of community consultation undertaken by Australian Wetlands in 2008 (refer Section 5) were specifically reviewed to ensure the values identified by the community are carried through and considered throughout the development of the EMS and Draft CZMP. The identified values are used to develop management objectives for the estuary (refer Section 7). Key statements describing the values identified by this process are provided below. Values have not been prioritised or ranked.

6.2.1 Economic Values

- The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy.
    - Agricultural practices occupy approximately 75% of the study area. Sugarcane is the dominant crop on the floodplain between Ballina and Coraki. Grazing land and cropping areas such as macadamia, tea tree and other mixed horticulture make up the rest of agricultural land use. Agriculture employs approximately 10% of the working population of the North Coast and makes up a significant portion of the local economy (WBM, 2006). The farm gate value of agricultural production in the North Coast Region was estimated in excess of $650 million (for the year 2000). In addition to this, the “add-on”value of agricultural-based industries contributed a further $1 billion to the regional economy (ABER, 2007). Although agriculture is identified as a key influence on the health of the estuary, management options need to consider and provide a balance between the economic and social values of the industry and environmental considerations.
    - Real-estate values and the associated rate base are recognised as a major driver of the local economy and are related to river health, the recreational opportunities a healthy river provides and scenic amenity.

- Fishing and oyster aquaculture contribute to the local and regional economy.
    - Commercial catch comprises mostly sea mullet and school prawns. Crab, eel and finfish (including sand whiting, bream, flathead and mulloway) are also significant commercial species in the estuary (WBM, 2006). Recent economic modelling of the direct and indirect benefits of the Ballina commercial fishing industry estimated total flow-on effects of $16.9 million derived from output, $2.9 million in generated income and the generation of 75 employment positions (Harrison, 2009).
    - There are 10 current oyster leases in the lower Richmond estuary. These are shown in the zone maps provided in Section 3.
    - Recreational fishing is a popular lifestyle choice for residents and visitors to the estuary with flow-on economic implications for local commerce including boat supplies, bait/tackle shops and tourism.
- The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits.
    - Tourism activities include recreational fishing, boating, swimming, holidaying, day trips, ecotourism, bird watching and nature appreciation. Tourism has been identified as a priority industry for the North Coast Region and was estimated to have a value of $646 million for the region (ABER, 2007).

Plate 16: Boating in the lower estuary

- The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore.
    - Rous Water has an entitlement to extract a maximum of 5,400ML/annum from the tidal pool upstream of Lismore on the Wilsons River for town water supply (NSW Office of Water, 2009).

- There are over 150 extraction licences for irrigation of agricultural lands located within the Richmond tidal pool making up 25% of the total entitlement for the unregulated system (NSW Office of Water, 2009).
- There are over 1,000 groundwater extraction licences with a total entitlement of 6,176ML/annum with 47% for stock and domestic purposes, 34% for irrigation and 18% for industrial purposes. Forty per cent of licences are located in the floodplain alluvium (NSW Office of Water, 2009).
- The Alstonville Plateau groundwater aquifers are also a major source of groundwater in the Richmond River catchment with water extracted for irrigation, stock watering and town drinking water supply (NSW Office of Water, 2009).

6.2.2 Social and Cultural Values

- The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities.
  - Fishing along the estuary is an important part of Aboriginal culture. There are many sites of Aboriginal heritage significance around the estuary and their recognition and protection is of high importance to the community.
- A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community.
  - European heritage items are related to key industries such as forestry and agriculture and associated transportation networks and include wharves, shipwrecks and heritage buildings in and around the estuary.
- The estuary and foreshore areas are highly valued by the community and visitors for recreational activities.
  - Activities include fishing, boating, swimming, surfing, walking and bird watching in the estuary and adjacent foreshore areas. It is important to the local community to have permanent public access to the ocean and foreshore areas.
  - The natural appeal of the estuary (e.g. Plate 16) should be preserved.
- Scenic amenity is valued highly by the local community and visitors.
  - Specific characteristics identified by the community include clean beaches and foreshore areas, presence of native flora and fauna (including threatened species), good water quality and appreciation of landscape, geomorphic and estuarine features.
- The estuary provides opportunities for both formal and informal education.
  - The ecological and cultural characteristics, economic aspects and management issues of the estuary offer a diverse range of educational opportunities for students and the general public.

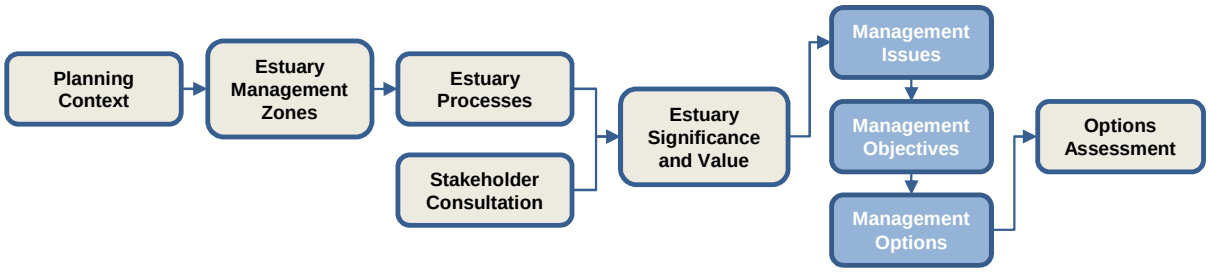
6.2.3 Ecological Values

- The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species.
    - This includes those protected under state and Commonwealth legislation, species of fisheries value and migratory birds protected under international agreements.
- The estuary supports a number of rare and threatened communities.
    - Examples are SEPP 14 wetlands, Endangered Ecological Communities (EECs) including Coastal Saltmarsh, Swamp Oak Floodplain and Littoral Rainforest.
- Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function.
    - The role of wetlands includes bed/bank stabilisation, cycling of nutrients and habitat for fisheries nursery and breeding grounds.
- The Richmond River estuary is recognised as one of the two most important locations for shorebird habitat in Northern NSW (DECCW, 2010b).
- The riparian zone provides a number of important ecological functions.
    - It provides wildlife corridors that create connectivity in a largely cleared and fragmented landscape. It also provides an erosion buffer for waterways to reduce and filter overland runoff of nutrients and contaminants. Additionally, riparian vegetation cover provides shade which reduces water temperature, increases dissolved oxygen levels and aquatic habitat and reduces aquatic weed.
- Good water quality is highly valued and considered a general indicator of estuary health by the community.
    - Water quality was given the highest priority during community consultation. The perception is that if water quality is good, then ecological, economic and social values will be preserved or enhanced.

Plate 17: Kingfisher at Swan Bay

Source: M. Wood

7. ESTUARY MANAGEMENT ISSUES, OBJECTIVES AND OPTIONS



The key issues affecting the Richmond River estuary were identified in the Estuary Processes Study (WBM, 2006; ABER, 2007; ABER, 2008). The following section outlines the current status of identified issues of the estuary.

Based on the established values of the estuary (Section 6) and the issues discussed in the following sections, management objectives have been developed.

The potential management options raised during this discussion are carried through to the options assessment process detailed in Section 8.

7.1 Options Development Process

Management issues for the estuary have been identified from the available background data in the EPS (WBM, 2006; ABER, 2007; ABER 2008) as summarised in Sections 3 and 4. The significance and values of the estuary have been derived from the scientific understanding of the estuary and the outcomes of the stakeholder consultation (refer Section 5). The identified values have been used to develop management objectives for the estuary. The management objectives are consistent with the goals and objectives of the NSW Coastal Protection Act, 1979, Coastal Policy, 1997 and Sea Level Rise Policy Statement, 2009 as described in Section 2.

For each major topic, the identified issues, related objectives and potential management options have been identified (but not prioritised or ranked) in the following sections. Section 8 summarises the ranking of issues and the assessment and prioritisation of the management options. Appendix 4 provides the full lists of management issues, objectives and options.

The Draft CZMP (Volume 1) describes the proposed actions to be implemented by the Councils and other public authorities to address priority management issues in the estuary over the implementation period.

7.2 Administration and Governance

7.2.1 Issues

Governance

The stakeholder groups involved with management of the estuary include:

- Three local councils (Ballina Shire Council, Lismore City Council and Richmond Valley Council);
- Council appointed and funded entities, Richmond River County Council (RRCC), Far North Coast Weeds (FNCW) and Rous Water;
- The Northern Rivers Catchment Management Authority (NRCMA);
- A range of State agencies and state funded entities (e.g. OEH, DPI);
- Private landholders;
- Indigenous Groups; and
- Community groups (e.g., Landcare, Bushcare and Coastcare groups).

The responsibilities of the local and state government agencies are discussed in Section 2.2. The development and implementation of the Draft CZMP will require collaboration between a range of stakeholders including all the constituent and county councils, state government, industry, landholders and community.

The governance of the Richmond River estuary is complicated with no overriding body responsible for its management as a whole. Management activities are currently carried out through a range of different programs, by the various stakeholders and through various sources of funding. For example, RRCC responsibilities are limited by legislation to projects related to floodplain management, with funding by the local councils. Together, the local Councils and various state government agencies are responsible for other natural resource management aspects of the estuary (such as pollution control, climate change, stormwater management, sewerage, environmental water management, land management, Crown lands, agriculture, fisheries and maritime issues).

The responsibilities of the local councils are defined by the Local Government Act 1993, but management effort is limited by:

- Council administrative boundaries – council management and funding priorities are usually limited to programs in their own LGA, without a holistic estuary-wide focus; and
- Pressures on available council funding (as a result of other competing council functions) limits the effort applied to estuary management.

The existing estuary management governance model is disjointed due to the multi-agency responsibility, lack of a holistic approach, financial constraints and inefficiencies in the delivery of management programs. The lack of coordination between the various management entities has been identified as a significant barrier to successful estuary management. Community confusion about the role of the various local and state departments in estuary management was also identified as an issue during the community consultation phase of this study. Improved governance arrangements will rely on clearly defined responsibilities and adequate funding to implement these responsibilities. Current legislated responsibilities do not allow any one party to provide the appropriate governance and administration role.

Planning Instruments

Permitted land uses within the study area are detailed in the LEPs of Ballina Shire Council, Richmond Valley Council and Lismore City Council. The LEPs are supported by a number of Development Control Plans (DCPs) to provide more detail in relation to controls for specific types and forms of development throughout each LGA.

The major land zonings/land uses in close proximity to the estuary are primarily rural zoned lands, which are used for cropping, grasslands and for grazing cattle. The EPS (WBM, 2006) also identified examples of poor urban development which have resulted in the loss of significant habitat areas and due to their proximity to the estuary are likely to be contributing pollutants to the waterways. Other key land uses in the study area in close proximity to the estuary include urban residential living. The EPS found that agriculture in the study area is having a variety of water quality impacts on the estuary. Although agricultural/urban land uses in the study area are known to be impacting on water quality within the estuary, the land use planning of local Council's currently supports these land uses.

No.	Administration and Governance Issues
I1	Lack of protection to estuaries through existing planning instruments
I2	Lack of good governance model for integrated decision making and coordination
I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management

7.2.2 Management Objectives

Table 4 shows the relationship between estuary administration and governance issues, related values and management objectives. Because administration and governance affects all aspects of the estuary, it is relevant to all the estuary values.

Table 4: Relationship between Estuary Administration and Governance Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community.	I1 - Lack of protection to estuaries through existing planning instruments I2 - Lack of good governance model for integrated decision making and coordination I4 - Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	O2- To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP O3 - To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.2.3 Potential Management Options

Administration and Governance

To address the administration and governance issues, the model for delivery of the estuary management program in the Richmond River needs to be reviewed. There is a clear need to facilitate efficient and strategic decision making, ideally within the current legislative responsibilities. Potential solutions to achieve this are:

- Empowerment of a single entity;
- A new partnership or trust; or
- More efficient administrative procedures and responsibilities within the existing governance arrangement.

A new partnership was implemented for the Clarence River Estuary (The Clarence Floodplain Project, CFP), hosted by local government (Clarence Valley Council) and including organisations, groups and stakeholders (the partners). The inclusive approach used to engage and involve floodplain landholders, stakeholders and project partners has resulted in widespread support and acceptance of the project in the Clarence Valley community. The Clarence Valley Council was formed through an amalgamation of Grafton City, Maclean, Copmanhurst and Pristine Waters Councils and the Lower Clarence and Clarence River County Councils. The hosting and involvement of a single local government body resulting from the amalgamation, may contribute to the success of the partnership. In the case of the Richmond River estuary, the various local government bodies and current division of responsibilities may reduce the success of such a partnership.

The governance arrangements are complex with various statutory implications to be considered. It is clear that further work is required to assess the current governance model and recommend modification or alternative arrangements taking into account the full suite of administrative, funding logistical and legal considerations. Therefore the recommendation of this study is to conduct a comprehensive review of the current governance and administration arrangements to direct further action.

Planning Instruments

Any future developments in the study area, in particular new urban subdivisions (identified by Council's in their urban land release areas) should apply a holistic management approach to the improvement of stormwater and water quality and the appropriate management of existing vegetative communities (i.e. rehabilitation of riparian vegetation and dedication of waterway buffer zones). This is discussed further in Section 7.7.

The absence of riparian vegetation has been found to coincide with areas of active bank erosion. Future planning controls and agricultural practices need to support better management of the riparian zone. This may involve Councils and other State Government departments dedicating riparian buffer areas on streams and waterways of the estuary and encouraging farmers to abide by these buffers and employ best practice land management techniques. Better management of riparian vegetation on existing Crown land and the preservation of foreshore Crown land for conservation is also a key consideration. The provision of funding incentives and labour assistance through existing funding avenues should also be offered to land owners to facilitate these actions. This is discussed further in Section 7.7.

No.	Administration and Governance Management Options
1	Conduct a comprehensive review of current governance and administration arrangements

7.3 Climate Change Adaptation

7.3.1 Issues

Natural variations in temperature and rainfall in NSW are influenced by the naturally variable climate systems. Although there is natural variability in the climate, there is consensus among climate scientists that the rate and magnitude of climate change that NSW is currently experiencing are outside the expected range of this natural variability. Climate change is an important consideration for strategic planning, particularly in coastal areas where the combined effects of sea level rise and increased storminess are considered key threats.

Tidal inundation of the stormwater network in Ballina currently occurs with king tides but no serious threats to public safety or built assets have been identified. Similarly, tidal inundation risk in the Evans River is currently not considered significant. However, the coastal hazards of tidal inundation and erosion within estuaries caused by tidal waters are expected to increase in severity and extent under climate change impacts, particularly sea level rise. Estuary bank erosion risks to development and infrastructure adjacent to the estuary is expected to increase in extent and severity under sea level rise scenarios.

The NSW Government's Sea Level Rise Policy (DECCW, 2009) states that sea level rise is inevitable and establishes planning benchmarks to be adopted in NSW. These benchmarks are an increase above 1990 sea levels of 40 cm by 2050 and 90 cm by 2100, an average increase of 0.8 cm per year.

Sea level rise in the Richmond River estuary is anticipated to result in issues including:

- Inundation and landward recession of low lying ecosystems;
- Increased salt penetration through the estuary and adjoining wetland systems;
- Increased erosion exacerbated by increased tide heights;
- Increased inundation of low lying lands, infrastructure and development; and
- Implications for drainage and flooding in urban and agricultural areas.

The EPS (WBM, 2006) states that sea level rise will increase the average depth in the estuary and that tidal propagation up the estuary and potential changes in salinity regime may be expected. It is anticipated that sea level rise will naturally result in the landward recession of fringing estuarine wetland systems. The location of estuarine habitats such as mangrove forests and salt marsh are controlled principally by tidal range and salinity influence and will gradually respond to changes in increases in average water levels and salinity. There is a risk that natural upslope migration of these wetlands will be curtailed by anthropogenic constraints such as roads, levees, agriculture and urban development on the landward side. Under these conditions the landward side of these important habitats will be fixed but the lower margin will gradually be pared away, leading to a loss of habitat area. Increased estuary levels will affect riparian and other low-lying vegetation in the freshwater reaches of the estuary in a similar way. Water-logging will gradually kill off the lower vegetation, whereas the upper boundary may be restricted. It is not currently known to what extent barriers to upslope migration will affect the wetlands and vegetation communities of the Richmond River estuary.

Akumu *et al*. (2010) modelled the potential impact of sea level rise on coastal wetland communities in Northern NSW. The model indicated that the area of mangroves, saltmarsh, transitional marshes and estuarine open waters will all increase by the end of the century. The area of tidal flats, non-tidal swamps, inland freshwater marshes and inland open waters all showed decreases according to the model. The modelling did not consider salinity affects, human impacts or physical barriers to migration but provides general indications of vegetation change that could be expected in an unmodified catchment and within the limits of the model. The potential changes in salinity regime and implications for estuarine ecosystems and adjoining land uses has not been fully explored. There may be

increasing pressure to reduce saline intrusion into low-lying farm lands and long-term floodgate management policies (see Section 7.5) will need to consider the implications of sea level rise and potential salinity increases. Similarly, more frequent flooding of low-lying urban areas, such as much of Ballina, creates risks for the estuary in terms of managing urban drainage impacts, potential effects on sewerage infrastructure and overflows.

The issue of potential increased storminess is less well understood. It is generally anticipated that rainfall events will become more intense, even if average rainfall reduces, in response to climate change. This may result in effects such as more floods as well as greater erosion of unconsolidated sediments within the catchment. It is not known whether key issues for the estuary such as blackwater related fish kills (see Section 7.5.1) will be exacerbated by climate change factors, however increased temperatures are expected to have implications for water quality.

No.	Climate Change Adaptation Issues
I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion
I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues

7.3.2 Management Objectives

Table 5 shows the relationship between Climate Change Adaptation issues, related values and management objectives.

Table 5: Relationship between Climate Change Adaptation Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • A number of European cultural heritage sites and items exist in and around the estuary and their acknowledgement and protection is important to the community • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality	I33 - Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion I34 – Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	O9 - To minimise constraints to estuary adaptation to climate change

7.3.3 Potential Management Options

Climate change is inevitable and planning benchmarks already exist in terms of future sea level rise (NSW Government Sea Level Rise Policy, 2009). Locally, there will be impacts from climate change that are unavoidable such as sea level rise and changes to rainfall patterns and therefore long-term management planning needs to consider the likely changes to the Richmond River estuary and the factors constraining adaptation to such change. An overall goal for the management of the estuary is to ensure that the estuary is as healthy and resilient as possible, so that it can respond naturally to the impacts of climate change.

Data on coastal hazards needs to be obtained to inform land use planning, floodplain and estuarine management strategies into the future. This should include assessment and mapping of the tidal inundation extent for the estuary and estimation of estuary foreshore erosion due to physical processes and flood events, both incorporating the NSW sea level rise benchmarks. With respect to tidal inundation, the CZMP Guidelines (DECCW, 2010c) require the assessment and mapping of the 1, 50 and 100 year ARI events for the present day, 2050 and 2100 planning periods. BSC is currently preparing a Floodplain Risk Management Study and Management Plan for the Lower Richmond which is scheduled for completion in late 2011. The coastal hazard of tidal inundation will be addressed through this process. The coastal hazard of erosion within estuaries should be investigated under consideration of projected climate change impacts as an action under the CZMP for the Richmond River Estuary.

In relation to the Evans River, RVC has completed an Estuary Processes Study (1999) and Estuary Management Study and Plan (2002) and is currently finalising the Evans Head Coastline Hazard and

Estuarine Water Level Definition Study. RVC plans to prepare a CZMP for the Evans River estuary and Evans Head coastline which will consider coastal and flooding hazards and identify management requirements.

The risks identified through the tidal inundation and estuary erosion hazard assessments will need to be addressed via development of appropriate management actions aimed at reducing the hazard risk to persons, development and infrastructure.

Similarly, the projected climate change impacts on estuary health need to be assessed. This should include impacts from increased tidal inundation of the estuary and increased flooding due to increased tail water levels under 2050 and 2100 sea level rise scenarios. Studies should be undertaken to evaluate potential estuarine wetland habitat distribution in the face of sea level rise and changes in tidal range and salinity in the Richmond River estuary. This information should be incorporated into planning instruments (e.g. LEPs) to ensure that upslope migration of key habitats can be accommodated within the long-term land use adjoining the estuary. As part of this, planning instruments should include provision for buffer zones and offsets as appropriate to achieve no net loss of mangrove, saltmarsh habitats and priority riparian habitats within the study area (refer Section 7.7).

Opportunities for carbon sequestration should also be identified as part of future land use planning.

The management of the floodplain's drainage network, including the operation of flood gates, modification of levees and drains as well as planning for future floodplain uses should ensure that climate change effects are considered. In particular, the possibility of increased flooding from higher ocean water (tail water) levels, high tidal inundation, more saline intrusion and potential for intense storms and flooding events, and how responses to these issues may affect estuarine health should be evaluated. This is discussed further in Section 7.5.

Climate Change is considered to be an overarching issue that will affect most of the issues associated with the estuary. It will be necessary, therefore, to consider the impact of climate change as an integral part of each management option and strategy.

No.	Climate Change Adaptation Management Options
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management

7.4 Monitoring and Evaluation

This section focuses on monitoring of water quality in the estuary. Other aspects of estuary health and the monitoring requirements are discussed in the relevant management strategies in the Draft CZMP (Volume 1) as well as this Draft EMS, namely:

- Riparian vegetation and erosion (Section 7.7);
- Vegetation and habitat management (Section 7.8);
- Waterway usage (Section 7.10);
- Wastewater management (Section 0); and
- Fisheries (Section 0).

7.4.1 Issues

Currently, water quality monitoring in the Richmond River Estuary is carried out primarily by local councils at specific locations for a range of purposes including mandatory monitoring of licensed discharges (STPs), State of the Environment reporting and 'Beachwatch' programs monitoring recreational water quality conditions. Other monitoring is carried out for specific projects or investigations, and have generally been short term in response to certain issues or events.

There is generally a good understanding of the major water quality issues for the estuary. A number of recent studies have investigated major issues associated with ASS, flooding and associated blackwater events and fish kills in the mid and upper sections of the estuary. However, some uncertainty remains regarding the sources of some water quality problems and the relative impact of various sources. One example is the periodic high levels of nutrients and faecal coliforms measured in North Creek. While the poor water quality episodes are recorded in the lower reaches, and a number of potential sources have been identified such as agricultural and urban runoff or STP input, the specific source of contaminants in this case has not been established.

Current monitoring does not provide a consistent approach over the catchment and therefore the identification and separation of specific issues and sources of water quality problems over time. Additionally, there is no integrated environmental monitoring and reporting system in place at a scale that is meaningful to determine the effectiveness of management and investment in programs and projects that affect the estuary. An effective ecosystem health monitoring program is regarded as a key component of an estuary management program in order to measure the relative success of management efforts on the overall health of the estuary. Specific investigations may also be required in targeted areas to fill gaps in the current understanding of water quality issues and sources in order to direct appropriate management actions as required.

No.	Monitoring and Evaluation Issues
I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts

7.4.2 Potential Management Options

To address the need for a more coordinated approach to water quality monitoring, the Northern Rivers CMA has commenced the Northern Rivers Ecosystem Health Monitoring Program (Ecohealth), a comprehensive marine, estuarine and freshwater monitoring program that reports on the health of our waterways. The program is modelled on the South East Queensland Healthy Waterways Partnership and the NSW State Monitoring, Evaluation and Reporting program. The program aims to bring together the aquatic sampling programs of government and other natural resource management agencies and partners into a standardised, region-wide system. A pilot project has commenced in the Bellingen catchment and is proposed to be implemented for the Hastings, Camden Haven and Coffs Harbour estuaries in 2010/2011. It is envisaged that the Northern Rivers EcoHealth program is eventually implemented across all catchments in the region, including the Richmond. Although the EcoHealth program is only at the pilot stage, it is expected that this program would provide the monitoring data required to effectively implement estuary management priorities.

A targeted approach to estuary management also requires a tool to support decision making. In particular, there is a need to determine the benefits of upstream improvement works on downstream water quality. Some tools have already been developed including E2 (Source Catchments) - a software product for whole-of catchment modelling developed by eWater, and the Coastal Eutrophication Risk Assessment Tool (CERAT) developed by OEH to help identify and prioritise land use planning decisions to protect and preserve the health of estuaries.

In response to complaints from oyster growers in North Creek regarding water quality, Ballina Shire Council plans to apply for funding to undertake a study to identify sources of faecal coliforms and nutrients in the catchments. This is discussed further in Section 7.14.3.

No.	Monitoring and Evaluation Management Options
2	EcoHealth monitoring program
3	Develop catchment/water quality modelling tool to support decision making
31	Further research into sources of water quality issues in North Creek

7.5 Floodplain Infrastructure Management

7.5.1 Issues

The Richmond River floodplain has been extensively modified by a complex network of constructed drains, modified canals, artificial levee banks and floodgates. Installation of floodplain drainage channels began in 1888 (Hendersons Drain, Tuckean Swamp) and accelerated in the early 1900s for the purpose of draining wetlands for agriculture and for flood mitigation. Floodgates were installed to prevent back-flooding of drains, creeks and tributaries and subsequently the inundation of agricultural land on the floodplain during minor flood events or by salt water from high tides. Drainage infrastructure is a dominant feature on the floodplain as shown in Figure 32 (floodgates represented by red icons; private drains shown as grey lines; RRCC managed infrastructure shown as coloured lines).

There are many types of floodgates in the Richmond River Floodplain, but the majority utilise the simple passive design, where the pressure of the downstream water seals the gate and when the downstream water level drops, the floodgates open to permit drainage. Floodgates are artificially lifted for cleaning and repairs and also for improvement in water quality, weed management, to provide greater control over surface and groundwater management. They can also be operated to allow for pasture inundation in some cases. RRCC currently has 44 actively managed floodgate systems totaling 141.5 kms of drainage and creek channels being tidally flushed and 6 more systems in the planning stages (RRCC, 2011). Tidal flushing is a dry weather strategy to improve water quality in drainage systems and positive results have been recorded during trials on the floodplain (refer Section 7.5.3).

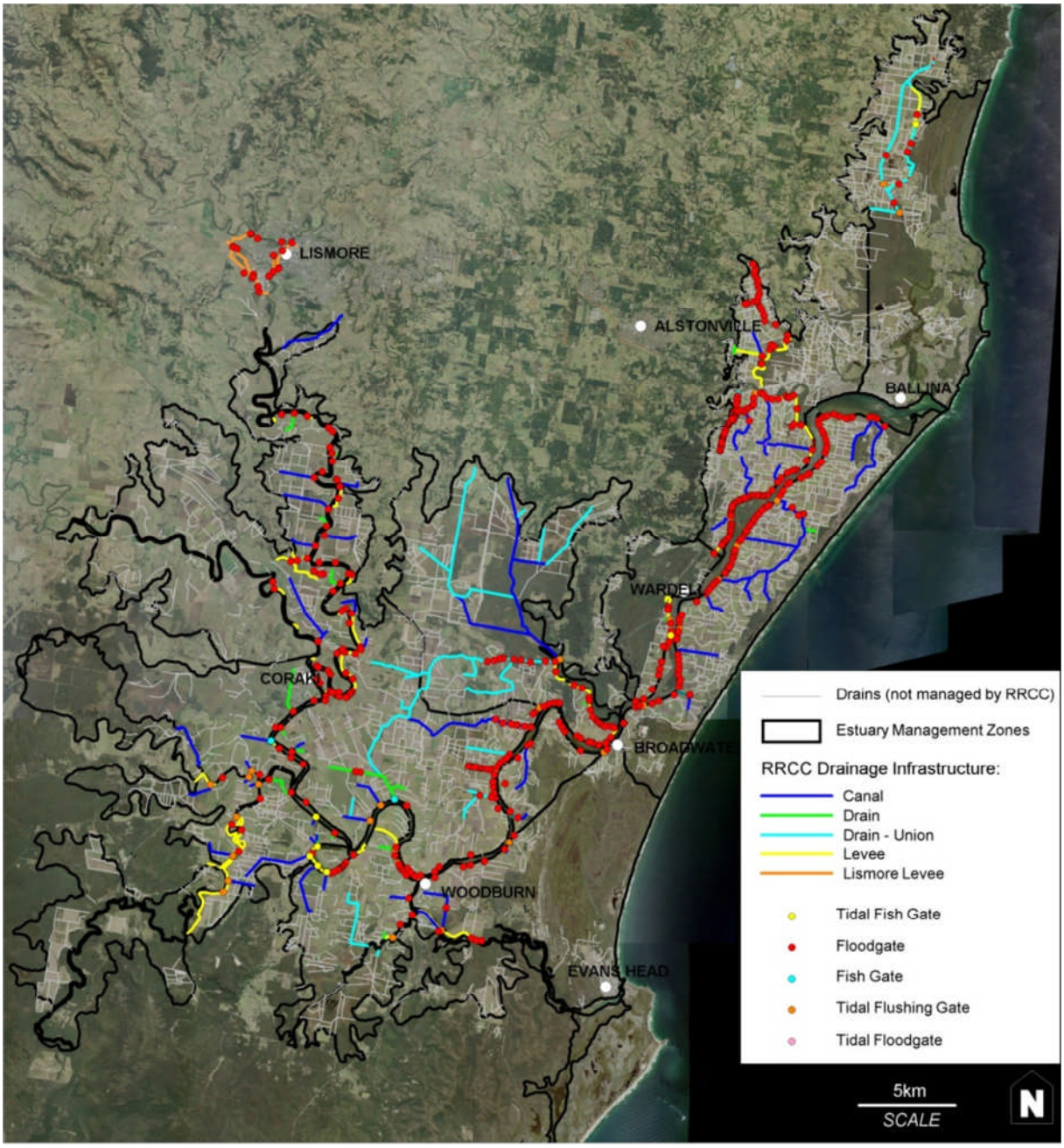


Figure 32 - Floodplain Management Infrastructure including assets managed by RRCC and other drainage

Source mapping data: RRCC

In recent research the issue of drainage infrastructure acting as a conduit for deoxygenated floodwaters brings with it considerations for floodgate management post-flood. The mass-drainage of waters was identified as having significant impacts on estuary health and cited as a key factor in the severity of fish kills observed in 2001 and 2008.

There is now recognition of the significant detrimental impact of floodplain drainage and regulation on floodplain wetlands, ASS management and water quality affecting the overall health of the estuary. Addressing the environmental impacts of floodplain infrastructure and management whilst maintaining adequate protection against flooding, is a key challenge for managing the on-going health of the estuary.

Plate 18: Closed floodgates on Empire Vale Creek, South Ballina

The Richmond River Estuary has a history of poor water quality episodes, particularly following flood events which are periodically associated with fish kills (Plate 19). While fish kills are a periodically occurring natural phenomenon, research has indicated that their frequency and severity are greatly exacerbated by floodplain modification (WBM, 2006).

Plate 19: Fish kill in the Richmond River (Ballina Quays Estate) in February 2008

Source: NSW Department of Industry and Investment – Primary Industries

The EPS (WBM, 2006) summarises the impacts of drainage structures as follows:

- Lowering of water-tables and preventing the natural ingress of river waters;
- Shifts from wetland vegetation species to vegetation intolerant of waterlogging;
- Increase in blackwater runoff events;

- Exposure of ASS and increase in chronic and acute impacts to aquatic biota; and
- Loss of agricultural land due to scalding by ASS, although the total areas affected were relatively small.

Table 6 shows a water quality risk assessment that was developed by the Richmond Floodplain Committee in 2007. The relative contribution of each sub-catchment to acid water and blackwater problems was estimated using local knowledge and experience. The impact on fisheries and overall biodiversity of the estuary ecosystem is also assessed including the scale of the impact. The three sub-catchments identified as presenting the highest risk to water quality in the estuary were the Tuckean (Zone 10), Rocky Mouth Creek (Zone 7) and Sandy Creek/Lower Bungawalbin (Zone 11) (also known as Swan Bay /Lower Bungawalbin). The right-hand side of the table provides an assessment of actions to date and how far specific strategies have been implemented.

The primary issues for estuary health associated with floodplain drainage are discussed in the following sections.

Table 6: Risk assessment of sub-catchments developed by Clay and Cabot (2007) on behalf of the Richmond Floodplain Committee.

Sub-catchments	Water quality problems			Impact on fisheries/biodiversity				Actions to date				
	Acid water	Blackwater from drain sludge (MBOs)	Blackwater from rotting vegetation	Impact upon fisheries	Impact upon Biodiversity	Localised impacts around floodgates	Impact upon entire estuary	Education effort by agencies & council	Site specific management strategies identified			Management strategies implemented
									Acid water	Blackwater from drain sludge	Blackwater from rotting veg	
Tuckean	h	h	h	h	h	h	h	h	yes	yes	no	partially
Rocky Mouth Creek	h	m	h	h	h	h	m	h	yes	yes	partially	partially
Sandy Creek / Bungawalbyn	m	m	h	h	h	h	h	h	yes	yes	partially	partially
Kilgin / Buckendoon / Dungarubba	h	l	m	h	h	h	m	m	partially	yes	partially	partially
Swan Bay	h	h	l	m	h	m	l	m	partially	partially	no	partially
North Creek/Newrybar	m	m	m	m	m	m	l	l	no	partially	no	partially
Emigrant / McGuire's Creek	m	l	m	l	m	m	l	l	no	no	no	nil
Lower Wilson/Richmond	l	l	h	l	l	l	m	l	no	no	no	nil
Sth Ballina / Empire Vale	l	l	m	m	m	m	l	m		no	no	partially
Back Channel	l	l	l	l	l	l	l	l	no	partially	no	partially
Evans	l	l	l	l	l	l	l	l	no	no	no	partially
Riley's Hill	l	l	l	l	l	l	l	l	no	no	no	nil

Acid Sulfate Soils (ASS)

ASS is the common name given to naturally occurring soils that contain iron sulfides, principally pyrite (Ahern *et al*., 1998). Un-oxidised pyritic soils are referred to as potential ASS (PASS). When the soils are exposed, oxidation of sulfides results in the generation of sulfuric acid and acid leachates. The soils are then referred to as actual ASS (AASS).

The formation of coastal ASS require the presence of iron-rich sediments, sulfate (usually from seawater), removal of reaction products such as bicarbonate, the presence of sulfate reducing bacteria and a plentiful supply of organic matter in a reduced (anoxic) low energy estuarine environment. The relatively specific conditions under which ASS are formed usually limits their occurrence to low lying parts of coastal floodplains, rivers and creeks (Ahern *et al*., 1998).

ASS materials in subsurface sediments do not pose a problem if left undisturbed. However, when exposed to air by either excavation or lowering of groundwater levels, the ASS materials oxidise and in the presence of water will form sulfuric acid and other acid products. This can occur through natural processes such as extended dry periods without rainfall resulting in a lowering of the water table and

formation of acid pools, which are later released during flooding events. Floodplain infrastructure including a combination of drains, floodgates and levee banks, artificially lowers groundwater levels, causing more frequent and extensive exposure and oxidation of ASS. Over extraction of groundwater can also lower water tables and expose ASS to oxidation. Figure 33 shows a conceptual model of ASS cause and effects developed for the Richmond River estuary including the impact of floodplain infrastructure. The model uses red arrows to show causative factors and green arrows to show factors that can potentially mitigate impacts.

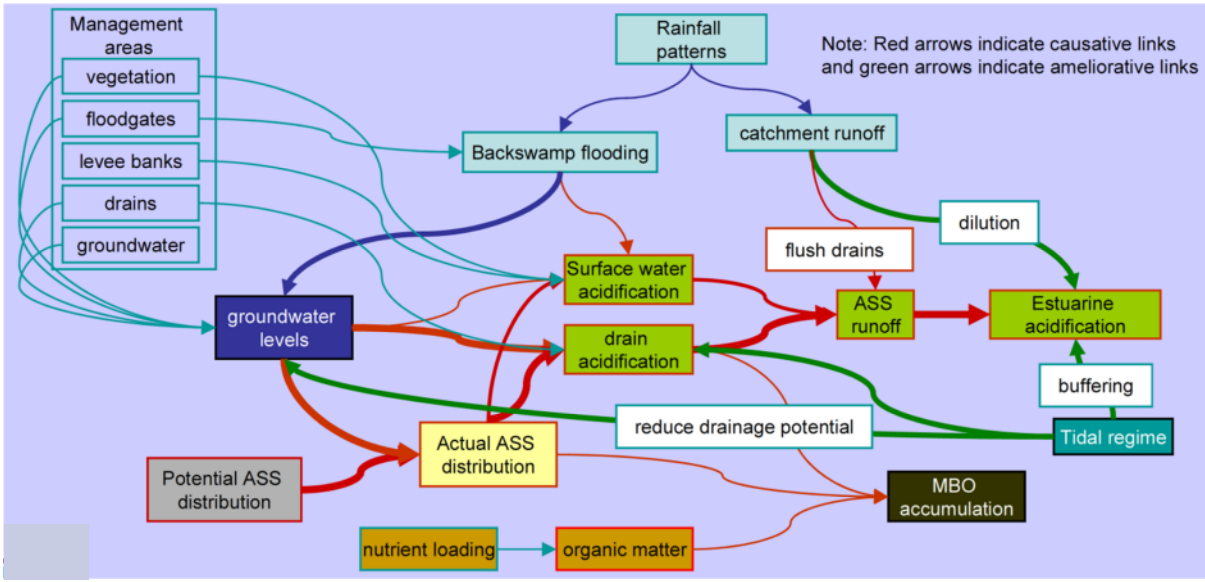


Figure 33 - Factors associated with ASS impacts

Source: ABER, 2007

ASS runoff impacts on the estuarine environment include low pH, high concentrations of toxic dissolved iron, aluminium and other metals (ABER, 2008). Exposure to ASS runoff can impair gill function and increase susceptibility to disease in fish, particularly Epizootic Ulcerative Syndrome (EUS), otherwise known as Red Spot Disease. Additionally, initial flushes of floodwaters in ASS environments can mobilise large amounts of MBOs from drain sediments which can cause local hypoxia events. Incidences of low pH in the lower estuary (i.e. near Ballina) are rare and are a result of the enhanced tidal flushing in these locations which act to neutralise, dilute and remove much of the acidic runoff from the estuary (WBM, 2006).

Approximately 68,000 ha of the Richmond River floodplain is classified as having ASS risk (WBM, 2006). The drainage and subsequent oxidation of ASS across the floodplain has resulted in chronic and acute discharges of acid and associated pollutants to adjacent waterways. Five priority areas for the management of ASS in the study area were identified and mapped by Tulau in 1999, during a state-wide study of ASS. Figure 34 shows the distribution of ASS hotspots across the study area. The Digital Elevation Model (DEM) created for the Richmond River Flood Study (BMT WBM, 2010) is provided as a base map for this figure to give an indication of the low elevation of the floodplain and specifically the ASS hotspot areas.

Priority ASS areas are:

- Tuckean Swamp;
- Rocky Mouth Creek;
- Sandy Creek – Bungawalbin Creek;

- Maguires Creek - Emigrant Creek; and
- Newrybar-North Creek.

Each of the above areas is discussed below in terms of the nature of the problem and current management activities occurring to address the problems.

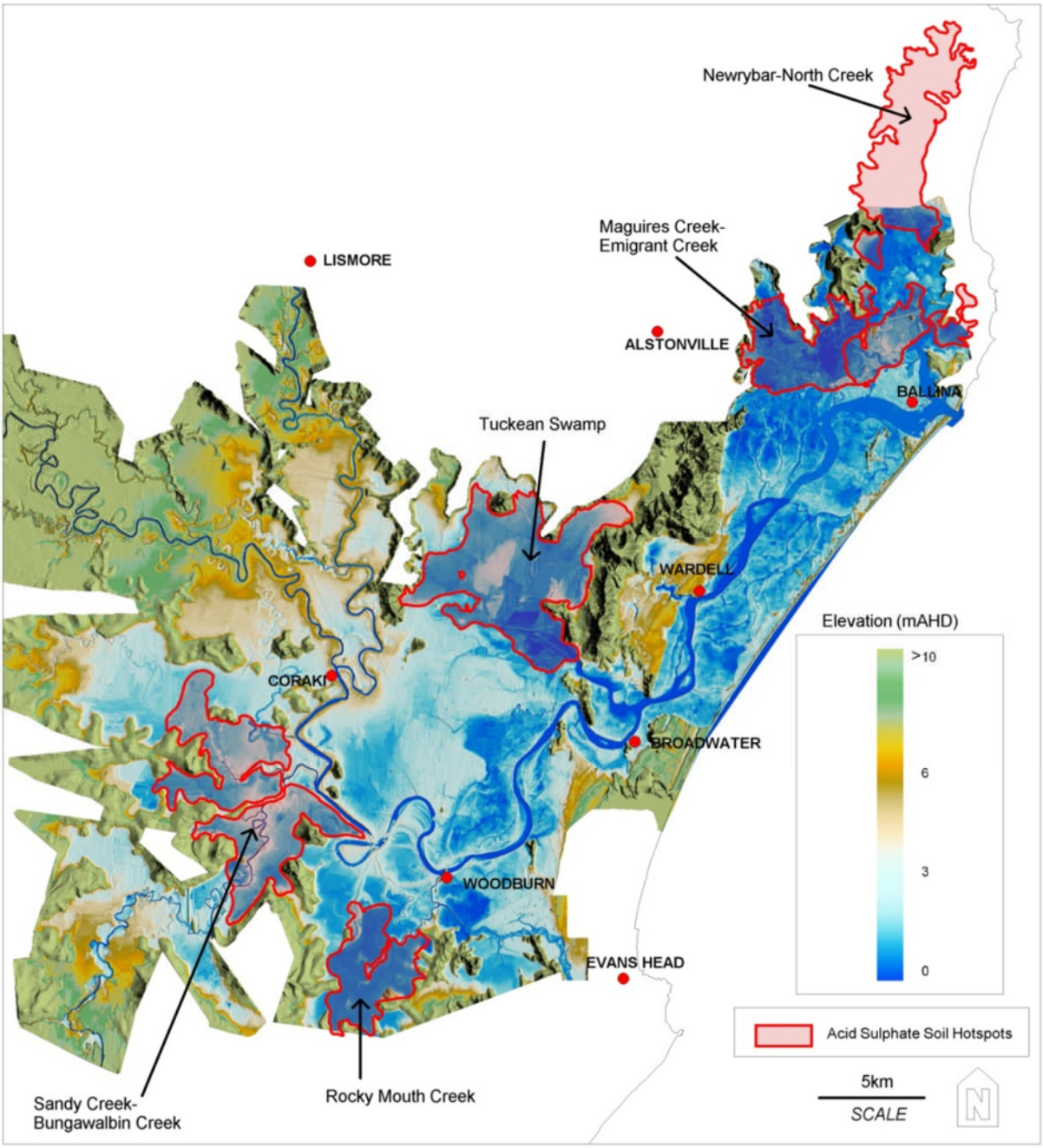


Figure 34 - ASS Hotspots shown over the floodplain Digital Elevation Model showing elevation
Source ASS Hotspots: Tulau (1999); Source of other mapping data, RRCC

Tuckean Swamp

Drainage of the Tuckean Swamp has dramatically altered the swamp's hydrology resulting in the widespread oxidation of ASS, and shifts in vegetation communities away from open wetlands to dry-land pastures and *Melaleuca* forests. The drainage system also provides a more efficient conduit for the transport of ASS runoff and blackwater to the estuary. Discharges from the Tuckean Swamp are commonly extremely acid (pH ~3.2) and contain high concentration of toxic metals such as dissolved aluminium (ABER, 2008).

The most northern reach of the Tuckean-Broadwater has been isolated by the construction of the Bagotville Barrage. Water quality has been significantly impacted by ASS runoff, which causes chronic acidification of the main and Meerschaum Vale drains and seasonal acidification of the upper reaches of the Tuckean Broadwater (Ferguson and Eyre, 1995). ASS runoff is characterised by high concentrations of dissolved metals (e.g. iron and aluminium), which rapidly precipitate as runoff mixes with estuarine receiving waters (Ferguson and Eyre 1999).

Rocky Mouth Creek

The Rocky Mouth Creek and Swan Bay consists of a backswamp draining to the Richmond River at Woodburn. Much of the backswamp area is below sea level and subject to rapid flooding after rainfall. The combination of low lying land and agricultural landuse have led to major water quality problems associated with ASS run off and blackwater, all of which are exacerbated by modified drainage. ASS runoff can be extreme and contains high concentrations of dissolved metals. The upper reach of Rocky Mouth Creek is prone to extreme acidification for extended periods of time following runoff events, with recovery greatly influenced by tidal mixing. Lin *et al* (2004) reported that acidic flows (ph<4.5) from May 1998 to July 2000, occurred intermittently for several months in the upper reaches. Dissolved oxygen data indicate that the creek is also prone to extensive periods of hypoxia due most likely to oxidation of ASS products or high biological oxygen demand (BOD) from floodwaters (ABER, 2008). Acid groundwater flows from Rocky Mouth Creek are also a significant contributor to acid flows.

Sandy Creek – Bungawalbin Creek

Draining of the swamps of Bungawalbin and Sandy Creek resulted in widespread shifts away from native wetland vegetation and towards oxidation of ASS (WBM, 2006). These areas now have active ASS which create considerable acid runoff via subsurface flows to the estuary. This sub catchment area contributes a large amount of flow to the main river channel and therefore has a major influence on acidification of the main estuary particularly during runoff events.

Maguire's Creek - Emigrant Creek and Newrybar-North Creek

Large areas of actual ASS are located in the north of the study area, in the upper reaches of North Creek and lower and mid reaches of Emigrant and Maquires Creek. Both areas have been extensively drained and are utilised for agriculture (mainly sugarcane and grazing land). Acidification has been noted as affecting water quality in the upper reaches of both North Creek and mid reaches of Emigrant Creek (ABER, 2008). In Emigrant Creek, acid water is known to become an issue following significant rainfall (Walsh *et al*., 2010). In the lower reaches, tidal flushing largely mitigates the impacts of acid runoff through the buffering effects of seawater. This was evidenced in ABER's (2008) low to medium risk rating for downstream acidification impacts from both zones.

Monosulfidic Black Ooze (MBO)

Monosulfidic black ooze (MBO) is created by rotting organic matter that is enriched with iron monosulfides. It is formed on drain bottoms and sides by bacterial catalysed chemical reaction when organic matter combines with iron and sulfur in a low energy reducing environment to form iron monosulfides (FeS). When disturbed and transported during flow events, MBOs have the capacity to rapidly deoxygenate water and severely disrupt the ecology of waterways (Bush *et al.,* 2003). MBOs form under conditions where there is low flow, an abundance of vegetation and high concentrations of iron and sulfur from ASS drainage. Flood-gated drainage canals through low lying backswamps over estuarine sediments provide excellent conditions for their formation (Johnston *et al* 2003). Fish kills associated with the disturbance and transport of MBOs have been reported for the Richmond River estuary (ABER, 2007). The Tuckean has one of the highest recorded concentrations on MBOs reported in the world (Bush *et al*., 2004).

Plate 20: Monosulfidic Black Ooze

Source: R. Bush

Blackwater Events

Blackwater is a collective term used to describe low oxygen floodwaters with high organic load emanating from backswamp areas following flood events (ABER, 2007). Blackwater may consist of inorganic blackwater from MBOs and/or organic blackwater from the decay of floodplain vegetation with the largest impact associated with organic blackwater. From early colonisation European land clearing on the floodplain has replaced flood adapted native trees and shrubs capable of withstanding floods with exotic grasses and crops which quickly die and decompose in summer when flooded. This was discussed as a major contributor to fish kill events in the Richmond River in the EPS (WBM, 2006) and recent studies have offered greater insight into the nature and extent of blackwater events (refer Section 4.2.1). Prolonged inundation of the floodplain during and immediately following flooding can cause the decay of the underlying vegetation and rapid decomposition of accumulated organic matter (Eyre *et al*., 2006). The decomposition process strips oxygen from the overlying water, creating 'blackwater'. The mass drainage of this ponded blackwater via the drainage network and tributaries as floodwaters recede can cause hypoxic (very low dissolved oxygen levels) conditions along large stretches of the estuary (Wong *et al.,* 2010). Aquatic life requires certain levels of dissolved oxygen in the water to live and when those levels drop, organisms will either escape to better quality water, or if this is not possible, they will inevitably die. When blackwater propagates through large areas of the estuary, as was seen during the 2001 and 2008 floods, major fish kills have occurred. Wong *et al*. (2010) identified the backswamp areas of the Tuckean, Rocky Mouth Creek and Bungawalbin Creek systems as the most significant sources of blackwater in the Richmond Estuary. Figure 35 shows the general location of the significant blackwater generation areas, using the DEM as a base mapping layer to give an indication of the low elevation at these sites.

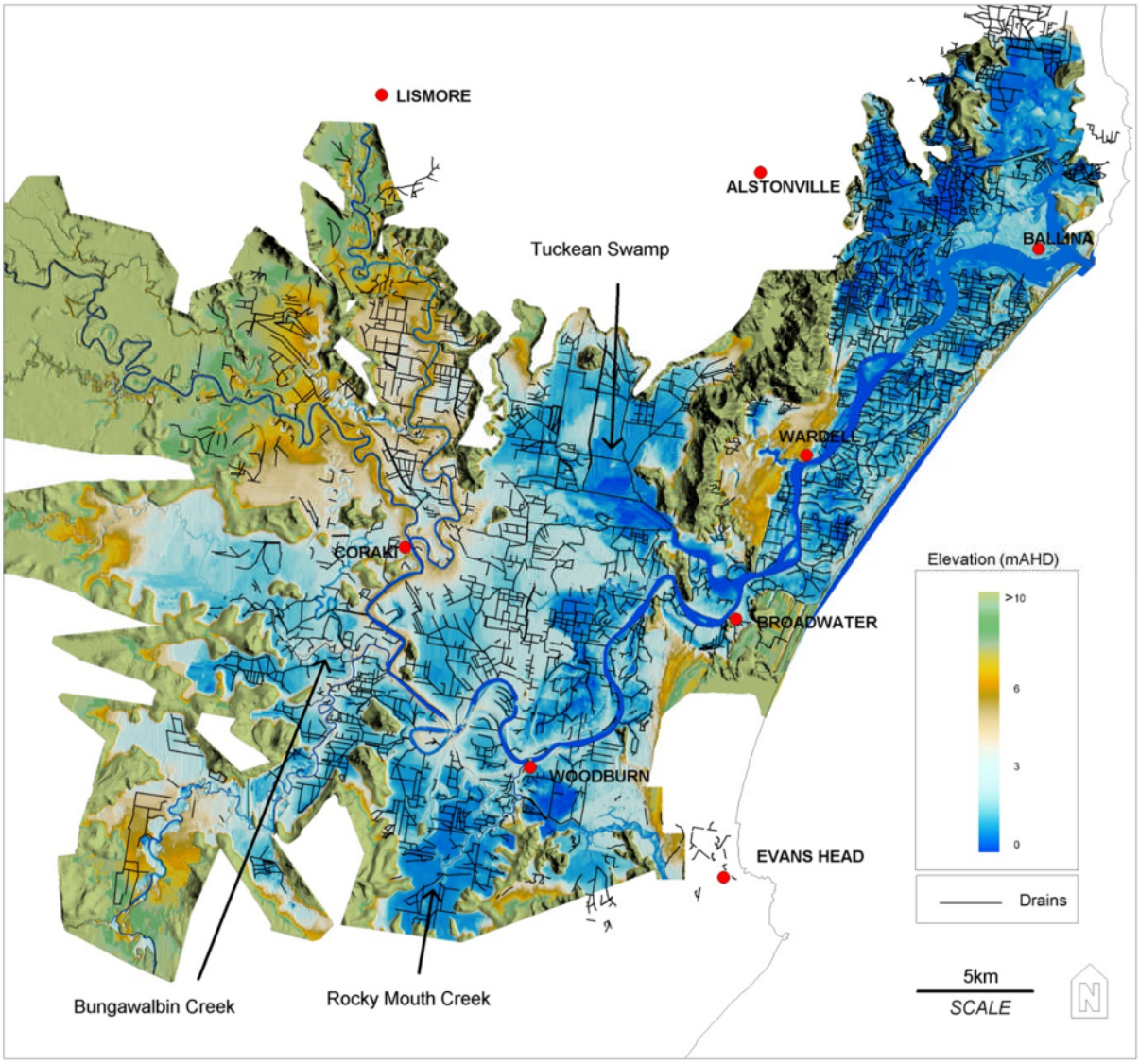


Figure 35 - Digital Elevation Model of the Floodplain showing low-lying areas (dark blue is at or below sea level), drains and identified blackwater source areas of Tuckean, Bungawalbin Creek and Rocky Mouth Creek

Source mapping data, RRCC

High water temperatures have also been found to be a significant factor in fish kills (Wong *et al.*, 2010) and this is likely due to higher temperatures leading to faster rates of decomposition and faster consumption of oxygen from the water and also because higher temperature water also holds less dissolved oxygen than cooler water.

A conceptual model of the Richmond Estuary February 2001 fish kill was developed by ABER (2007) illustrating the relationship between various factors contributing to blackwater events. The conceptual model is shown in Figure 36 over a time scale relative to the flood peak and recession. The frequency and extent of kills is determined by a complex interaction between these factors. As such, prediction of fish kills is difficult, however an understanding of primary drivers is important to inform mitigation strategies. Walsh *et al*. (2010) compared conditions during floods that result in fish kills against those that did not, and found that fish kill floods have significantly drier preceding conditions followed by short, sharp summer flood peaks. This finding highlights the fact that climatic influences and catchment conditions leading up to flooding as well as the flood magnitude and duration have a large influence over blackwater fish kills. The model also demonstrates the impact of drainage and flood mitigation works in creating much drier floodplains and hence a more frequent trigger for fish kills.

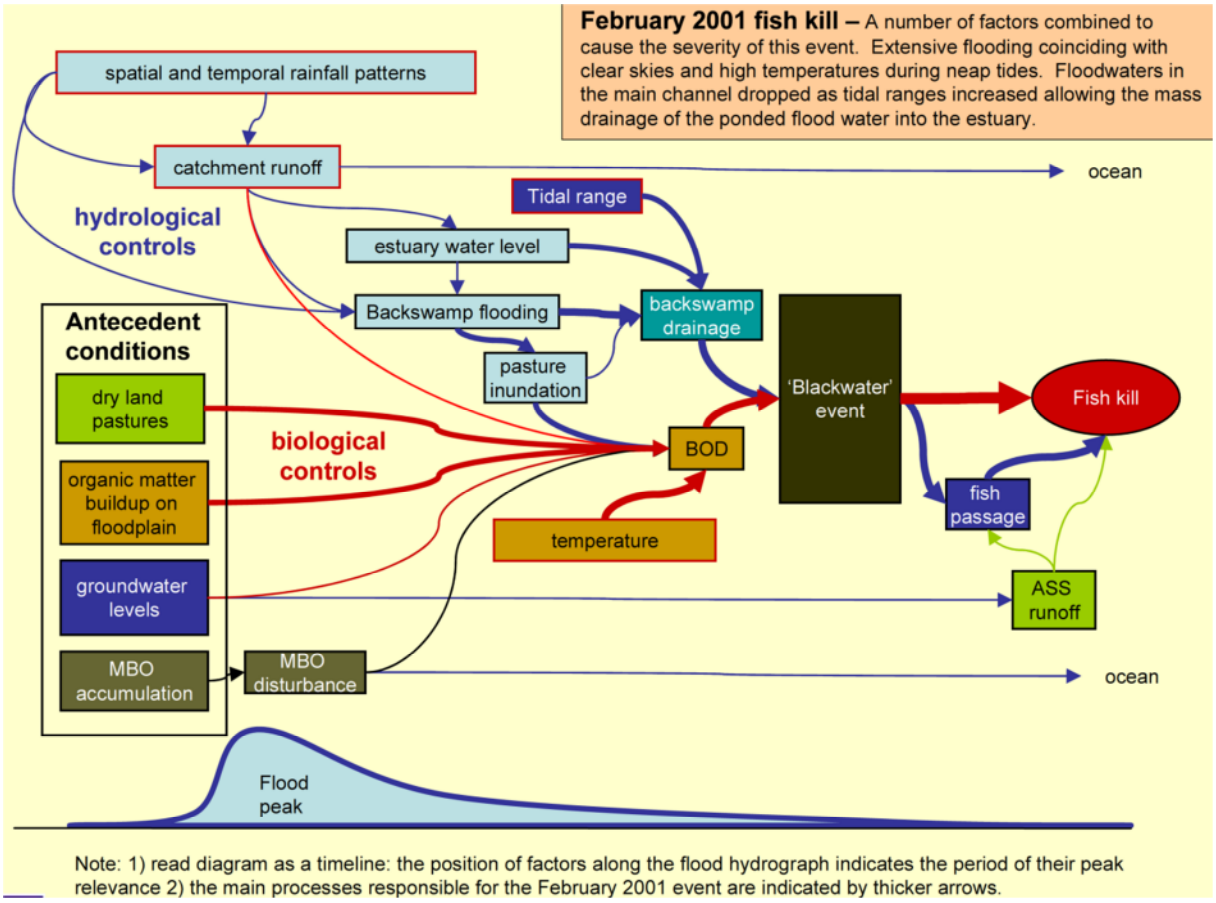


Figure 36 - A conceptual model of the Richmond Estuary February 2001 fish kill illustrating the relationship between various factors contributing to blackwater events

Source: ABER, 2007

While blackwater events have been recorded prior to floodplain drainage, the construction of drainage infrastructure on the Richmond floodplain has contributed significantly to blackwater production and impact by increasing the rate at which blackwater is produced and increasing the rate of delivery of blackwater to the main river channel (Walsh *et al*., 2010). The combination of floodplain drainage infrastructure (drains, levees and floodgates) creates much drier soil conditions during non-flood periods and facilitates the draining of freshwater from floodplain backswamps. Furthermore, original floodplain vegetation that was adapted to frequent inundation has been replaced by vegetation that is dominant under drier conditions (particularly pasture). The vegetation on drained floodplains is generally intolerant of waterlogging and consequently decomposes faster and demands more oxygen after inundation (Eyre *et al*., 2006). Another factor that exacerbates the impacts of blackwater events is the swift delivery of blackwater to the river via extensive drainage systems. These act as a conduit for blackwater to the main river channel as floodwaters in the main channel drop (Wong *et al*, 2010).

Plate 21 - Blackwater discharging from a drain into the acidified Richmond River at Swan Bay

(R. Bowie, 1996)

No.	Floodplain Management Issues
I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)
I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary
I18	Floodgates affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils
I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.

7.5.2 Management Objectives

Table 7 shows the relationship between Floodplain Management issues, related values and management objectives.

Table 7: Relationship between Floodplain Management Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species	I10 - Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events I11 - Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary I18 - Floodgates affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils I19 - Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	O7 - To minimise the frequency and severity of environmental events such as fish kills O8 - To optimise flood mitigation works and flow control structures to improve estuarine water quality

7.5.3 Potential Management Options

In general, any management options that move towards the reinstatement of a more natural flows and restoring floodplain ecosystems would be a step towards improving water quality and general estuary health. There are a range of management options that have been developed through technical research and scientific trials both within the Richmond River catchment and at other locations. The effective application of various management options is dependent on a number of site specific factors and a case by case assessment of specific sites is required to recommend appropriate actions. Options identified for management of ASS, MBOs and blackwater issues are summarised below.

Acid Sulfate Soils

Several on-ground works are currently being implemented to manage ASS within the estuary management zones. Management actions include floodgate management and infilling and/or reshaping of drains for groundwater control. These methods seek to manage ASS by reducing the exposure of pyrite within the soil profile to air. By submerging the ASS, the risk of oxidising the pyrite within the ASS and subsequent acid leachate being released into the drains and downstream watercourses is reduced. These activities also reduce the interception of iron and aluminium rich groundwater and reduce the extent of accumulation of monosulfidic black oozes behind the floodgates.

Plate 22 - Floodgates on Tuckombil Canal, Evans River

Managing floodgates for tidal flushing has allowed for buffering of acid build-up (Moore, 2007). RRCC actively manage most of the major flood gated systems to allow tidal flushing where practical Floodgate management trials were conducted by RRCC on the Tuckean Barrage in 2002. Water quality monitoring showed that tidal flushing during dry times can decrease the build-up of acid waters upstream of the barrage and improve aquatic habitat. Even though water quality can quickly decline following rainfall, due to ASS runoff, the tidal flushing offers at least periodic improvements in water quality. Groundwater management, drain remodelling and drain infilling have also been conducted at various sites within the floodplain. In-filling and shallowing can also be used to partially restore former wetland floodplain hydrology, with subsequent water quality improvements.

These management actions have had major effects on reducing ASS exposure, oxidation and acid export. ABER (2008) reported on water quality improvements observed following drain management initiatives by RRCC. An example is provided in Figure 37, showing improvements in water quality (increase in pH levels) during dry periods related to partial infilling (installation of sills) of the Meerschaum Vale channel in 2005. The Floodgate Drain Management Guidelines (RRCC, 2006) provides guidance for RRCC staff, private contractors and landholders to undertake ‘Best Practice’ in flood mitigation drain and floodgate management. A review of the guidelines is recommended in association with review of floodgate management protocols to ensure the guidelines are updated with the latest information (scientific innovations, legislation, planning changes, best practice etc.), particularly with regard to sea level rise implications and the effects of blackwater releases via drains and floodgates to the Richmond River post-flood.

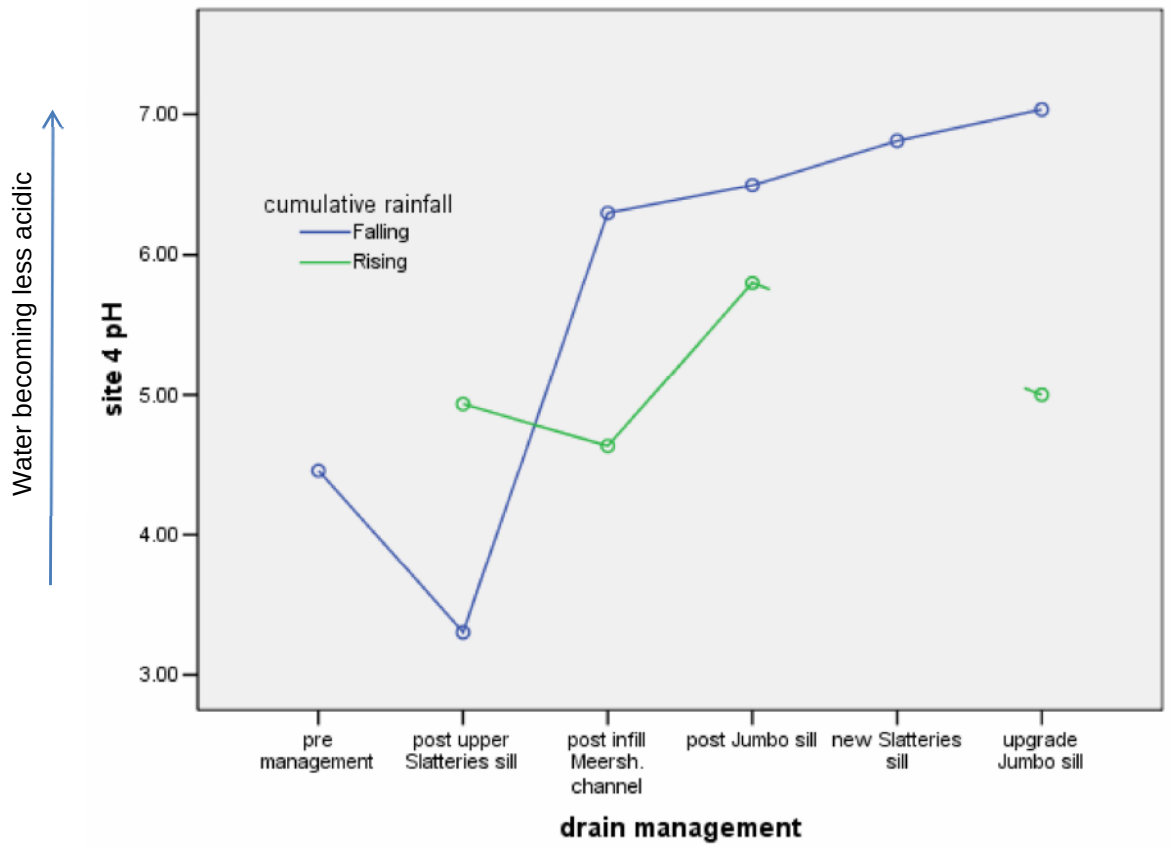


Figure 37 - Impacts of drain management initiatives on pH in the Tuckean

Source: ABER, 2008

During development of the Draft EMS, concerns were also raised about the effect of groundwater extraction on drawdown of the water table and resulting ASS effects. These concerns were specific to the area upstream of Ballina Nature Reserve in Zone 1 North Creek/Newrybar, which is an ASS hotpot area. There are several existing groundwater licences in the area and there is uncertainty about the effects of extraction on ASS effects. A review of Water Sharing Plans for the area in relation to groundwater extraction levels compared to freshwater recharge and considerations for sea level rise, will provide further understanding of ASS effects.

Blackwater

Walsh *et al*. (2010) recently conducted an assessment of blackwater mitigation options for the Richmond River Estuary. Options were compiled in consultation with the Estuary Floodplain Committee. Each option was assessed in terms of benefits (pros) and costs (cons). The options assessed were:

- Do nothing;
- Retain post-flood water inundation;
- Wet pasture management;
- Floodgate management;
- Laser levelling;
- Drain shallowing;
- Alternative land uses / crops;
- Remove vegetated biomass from floodplains; and

- Replace pastures with trees and shrubs.

Walsh *et al*. (2010) concluded that the identified options have a range of positive benefits for managing blackwater, and other issues such as ASS and MBOs. In terms of managing blackwater, the study identified a number of gaps in the current understanding related to specific details of on-ground application and also the extent to which specific management options will affect overall estuary health. Further studies were recommended to trial certain management activities (e.g. floodwater retention on backswamps) and fill these data gaps. An important part of scientific trials will be to review current and past work such as conducted at Clybacca and Little Broadwater and to build on existing knowledge.

Management actions as described above (apart from the do-nothing option) provide significant opportunity to improve water quality and minimise acid and blackwater events. On-ground application of these techniques and combinations of options varies significantly between the various sites. What may work in one particular area may not be successful in others due to site variation, and a range of potential environmental, economic and social constraints. There are also a number of other considerations that may constrain the implementation of effective management including landowner consent, suitable incentives for landowners, funding and resourcing arrangements, the age of existing drainage infrastructure at a particular site, legislative requirements and approvals. It will be necessary to carry out detailed on-ground assessment of each site to recommend an effective suite of management actions.

It is important that strategies are monitored to adequately gauge their success, assist with the planning of future rehabilitation techniques and to improve the understanding of how ecosystems respond to changes over time. The succession of landholders will also be of interest to monitor as changes in ownership of properties can also involve changes in land use and intensity with flow on consequences for on-ground projects to address floodplain drainage impacts. An audit of current active floodgate management practices is required to identify how well the current management activities are proceeding and whether changes to these arrangements are desirable.

No.	Floodplain Management Options
4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage
5	Identify and prioritise levees for redesign and/or remodelling
6	Review floodgate management protocols
7	Cost benefit analysis of backswamp farming activities
8	Scientific trials to investigate strategies for retention of water on backswamp areas
9	Changes in pasture management including changes to inundation tolerant pasture species
10	Retirement/buy back backswamp areas and return to wetlands
11	Work with backswamp property owners to identify alternative management strategies
21	Review water sharing plans regarding groundwater extraction and ASS effects

7.6 Farm Management

7.6.1 Issues

Agriculture is an important contributor to the local economy and is a key component in the social fabric of the region. Agricultural land use and some management practices are also identified as one of the major causes of poor water quality in the catchment and contribute to a broad range of issues in the estuary. Addressing the impacts of agricultural land use on the estuary, while continuing to enhance the local economy and protecting rural lifestyles, is one of the biggest challenges facing long-term management of the estuary.

Approximately 75% of the Richmond River estuary study area considered in the EPS (WBM, 2006) is zoned for various forms of agricultural use. Management of these lands has a large bearing on future outcomes for estuarine values. Key issues relating to farm management are discussed below, as well as in Section 7.7 (Riparian Zone Management) and Section 7.5 (Floodplain Infrastructure Management) where farm related practices have a large influence.

Sediment, nutrient and chemical runoff

Sediment, nutrient and chemical runoff from agricultural land can be significant. The EPS (WBM, 2006) cites work undertaken in 1999 that estimates fluvial sediment loads to the estuary of 678,000 tonnes per year, with 85% generated by sheet and rill erosion of unconsolidated sediments. Hossain *et al*. (2001) investigated the timing of sediment inputs and showed that the majority (~97%) of catchment based sediment load to the estuary was generated during the wetter parts of the year. Although small flow events will transport and deposit this material within the estuary, large floods will flush these sediments completely from the system (Hossain *et al*., 2001).

The EPS (WBM, 2006) evaluated potential nutrient loads to the estuary and reported catchment total phosphorus input to the estuary of over 483 tonnes per year of which grazing (45.5%), cropping (21.6%) and horticulture (12.4%) were major contributors. McKee *et al*. (2000) found that 97% of the total nutrient load to the estuary was derived from diffuse sources. A large proportion of both nitrogenous and phosphatic fertiliser inputs are not utilised by the crops and animals within the catchment and may be lost by leaching or runoff to the downstream waterways. During the McKee *et al*. (2000) study, fertiliser inputs were found to account for 65.5% of the phosphorus and 26% of the nitrogen loads generated within the catchment.

As with sediments, it was concluded that the majority of flood-bourne nutrient loads delivered to the estuary are directly transported off shore when the estuary is flushed to the mouth (WBM, 2006). However, post-flood and during non-flood periods, particulates, organic matter and nutrients are deposited in sediments and the water column recycles the bioavailable nutrients (ABER, 2007). Several sites within the study area experience periodic eutrophication and this is controlled by complex nutrient cycling processes.

Threats to ecological processes in the water column related to farming practices were identified by ABER, 2007 as:

- Increased nutrient loadings due to diffuse and point sources may increase phytoplankton productivity and hence organic carbon loading (“eutrophication”). This has implications for dissolved oxygen concentrations, invertebrate, and fish ecology; and
- Increased phytoplankton biomass and turbidity associated with catchment-derived suspended solids cause an increase in light attenuation, and in extreme cases may result in dissolved oxygen stratification, with hypoxic conditions persisting in bottom waters.

Within the benthic zone, turbidity and phytoplankton blooms associated with point and diffuse sources will lower the relative importance of benthic production and cause a shift towards the detrital pathway (ABER, 2007).

The use of agricultural chemicals in the catchment and subsequent runoff is a potential issue, although ever-increasing regulation of the industry (e.g. the recent ban on the use of endosulfan with two year phase out period) has greatly reduced the risk of widespread contamination however community concern about the potential for contamination remains. There are some industries reliant on the estuary such as oyster aquaculture (see Section 7.14.1) that are particularly susceptible to contamination of this type.

Stock access to waterways

Allowing stock to access waterways is a common farming practice which alleviates the need to provide off-stream watering and allows stock access to fresh feed and shade within the riparian margin. Although usually confined to freshwater riverine reaches, the EPS (WBM, 2006) reports that cattle also access some mangrove areas within North Creek and Emigrant Creek.

Stock usually gain access to waterways through unfenced creek boundaries, often in areas where riparian vegetation has been cleared to the water's edge. Cattle herds will repetitively access the creek through the same areas, and the concentration of animal traffic in these locations leads to soil pulverisation, rut formation and areas of soil instability. Immature trees and shrubs are either grazed or trampled whilst larger trees become destabilised as soil is eroded from around their roots. Stock will wander along river banks to access other grazing or shade areas and can therefore impact large lengths of stream through relatively few access points.

Sediment loads into the estuary are likely to have increased in response to grazing pressures in the catchment. This is likely to have resulted in increased turbidity, with consequent flow-on effects to estuarine ecosystems and productivity (WBM, 2006).

Bank instability and high grazing pressure prevents re-establishment of native riparian vegetation in cattle impacted areas and results in increased weed infestation of riparian zones. This is further discussed in Section 7.7.

Plate 23: Cattle grazing the banks of the Richmond River near Casino. The green tinge to the water indicates an algal bloom.

Cattle urinate and defecate directly in the water, hence creating direct sources of nutrients and faecal contamination which is bourne downstream to the estuary every day of the year. Stock will also often become trapped in soft sediment and flood debris within the creek margins and may drown. Dead animals act as a source of contamination and an aesthetic and health issue and represent a loss of farm income.

Pasture Management

As discussed in Section 7.5.1, land clearing on the floodplain and the establishment of exotic grasses and crops has resulted in the dominance of flood-intolerant vegetation. The decomposition of organic matter following a flood has been found to be a major contributor to fish kill events through the creation of blackwater. This is exacerbated by the decomposition of flood-intolerant pastures and the resulting high oxygen demand. Similarly, the deoxygenation potential of slashed pastures, harvested tea tree and cane trash is high and retention of this vegetative matter on the land also contributes to the risk of blackwater during floods.

Lack of incentive for change

Farming practices are developed over generations and can be retained for generations. Although there is increasing awareness of farming impacts on waterways within the farming community, strategies to address issues are not always evident and farmers do not always have access to the information required to make informed decisions. Industry guidelines and standards may not address issues that have significant impacts on estuarine health as they are not usually written for that purpose.

The costs and benefits of alternative management approaches to high impacts activities needs to be undertaken at a farm scale and requires the individual landholders to be involved. Farmers do not always have access to the appropriate information, skills or guidance to allow a proper cost benefit analysis of alternative practices to be undertaken.

A key lack of incentive to alter farming practices is the economic viability of such changes, particularly in the short-term where payback from up-front investment in more sustainable practices may leave significant farm revenue gaps. Economic initiatives that may be available to assist landholders are often dependent on short-term funding that is not consistently available. Additionally, knowledge of such incentives or the time to apply to gain access to such incentives may be not be available. It may be helpful to identify and target the catalysts for change such as change in landuse, change in ownership or when key infrastructure needs to be upgraded (e.g. publicly funded flood mitigation structures).

No.	Farm Management Issues
I1	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary
I6	Unrestricted stock access causes vegetation damage and bank erosion.
I7	Lack of incentive for landholders to address bank erosion
I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear
I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment
I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, and water quality issues

7.6.2 Management Objectives

Table 8 shows the relationship between farm management issues, related values and management objectives.

Table 8: Relationship between Farm Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community • Scenic amenity is valued highly by the local community and visitors • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function	I1 - Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary I6 - Unrestricted stock access causes vegetation damage and bank erosion. I7 - Lack of incentive for landholders to address bank erosion I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear I22 - Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment I34 – Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, and water quality issues	O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment O2 - To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP O6 - To protect and enhance the riparian zone O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain O9 - To minimise constraints to estuary adaptation to climate change O5 - To reduce pollutant loads to the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary

7.6.3 Potential Management Options

Issues associated with agricultural land management are some of the most widespread and culturally challenging aspects of catchment management. In terms of the Richmond River estuary, the high level of agricultural land use means that any widespread changes in farm management will have a large bearing on the conditions of the estuary.

Riparian fencing is often recommended to protect riparian areas from stock damage. This strategy is rarely effective when undertaken in isolation from a comprehensive stock management strategy implemented on a stream reach basis. Construction of reliable off-stream stock watering facilities, provision of adequate pasture shade trees and ensuring on-going riparian fence maintenance is undertaken are key actions required to avoid stock access to waterways. With these measures in place, bank stabilisation, riparian vegetation regeneration and weed control often needs to be undertaken for several years before long-term improvements can be realised.

Careful strategic planning is required on a property by property basis to ensure that the implementation of such measures will be successful and that the farm can continue to operate as a sustainable commercial venture. Although continued provision of information to the farming community

is essential, it is unreasonable to expect that change will occur without planning assistance and continued incentives to change current unsustainable practices.

Options to address farm management impacts on the estuary are as follows:

- A high level evaluation of agricultural land is required to identify and prioritise those farming properties where tailored farm management plans are likely to result in the most benefits for the Richmond River estuary. This prioritisation study should consider up to date land-use mapping, agricultural industry sector, presence of other property risks (e.g. ASS, back swamp pastures – see Section 7.5), hydrological proximity to the estuary as well as other information that may indicate property owner willingness to participate. A social network study conducted by CSIRO and James Cook University in 2008 is an example where this sort of information was gathered efficiently through initial phone surveys;
- Preparation of farm management plans for priority properties. The plans should document implementation strategies to address specific environmental issues including stock impacts, riparian zone degradation, soil loss and erosion, fertiliser and pesticide use and storage, drainage, pasture/crop harvesting and management as well as a long-term farm economic plan and long-term strategy for adjustment to more estuary-friendly land uses;
- Provision of extension services and incentives to farmers to change farm or property management practices. Incentives could include supply of material, labour, buy back and/or long term stewardship payments or other compensation programs. Properties bought back would require ongoing management by a Government department, agency, community group or Non-Government Organisation (NGO). Another option is voluntary purchase and resale with a conservation covenant attached, such as the NSW Nature Conservation Trust covenant program.
- Identify and liaise with agriculture industry bodies to discuss agriculture related issues in the Richmond River estuary and seek to provide information for inclusion in industry documentation such as best practice guidelines, codes of practice and waterway health certification; and
- Continued provision of educational material that is accessible to landholders within the catchment on ways to improve their farm management practices. This option should include or provides links to a comprehensive internet resource as well as public displays at agricultural events (e.g. Primex) and industry forums where appropriate.

No.	Farm Management Options
12	Farm management planning for priority properties
13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines
14	Identify high impact farming activities and investigate alternatives

7.7 Riparian Zone Management and Erosion

7.7.1 Issues

Riparian habitats are a significant component of estuarine and floodplain environments. Riparian zone functions include fisheries habitat, terrestrial habitat, bank stability and maintenance of soil structural integrity, land use buffering, water quality filtering, lowering water temperature and reducing aquatic weeds as well as providing scenic amenity.

Riparian Zone Condition

The EPS (WBM, 2006) compiled available mapping of broad vegetation types within 100m of waterways conducted by NPWS (2005) and DPI (2005). Detailed mapping data for riparian vegetation and the extent of weed invasion throughout the study area is not currently available.

More recently, work carried out by Australian Wetlands (2010, attached in Appendix 2) assessed the riparian vegetation of the Richmond River, however the assessment was limited to written descriptions of the study areas based on on-ground rapid assessment and broad mapping of riparian widths across the catchment. The main findings were that the riparian vegetation bordering the Richmond River Estuary and tributaries was degraded for much of the area. The width of the bank vegetation was often <5 m and few native trees remained. Serious weed invasion was occurring on the banks as there was no natural vegetation to inhibit the growth of weeds. There are some areas of remnant vegetation with good native canopy and mid-storey trees, particularly mid to upper Bungawalbin Creek and tributaries, mid North Creek and parts of the lower Estuary, but these are relatively rare within the estuary as a whole. The lack of riparian vegetation also allows the growth of aquatic weeds in some areas such as Sandy Creek through a combination of both nutrient and light availability (Owers, 2005). The EPS identifies the limited coverage and poor condition of the riparian zone as a key issue affecting overall estuary health (WBM, 2006).

Major disturbance factors for riparian vegetation in the Richmond River catchment are:

- Clearing of the bank/riparian vegetation;
- Ongoing disturbances associated with unrestricted stock access to banks;
- Lack of suitable buffer zones between land use and waterways, which is particularly; significant in areas of high soil disturbance such as cropping areas on steep slopes;
- Disturbance associated with infrastructure including waterfront structures and roads in close proximity to the river;
- Weed invasion; and
- Disturbance associated with periodic flooding.

Bank Erosion

Bank erosion can lead to a range of environmental, social and economic problems such as the loss of riverfront property and infrastructure, water quality degradation, destruction of natural and artificial levees, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals.

Water quality issues associated with erosion include high turbidity and the mobilisation and transportation of nutrients and contaminants associated with sediment from land to waterways. Sedimentation in the main river channel is not considered to be a significant issue as most of this sediment is thought to be transported to the ocean during major events, with very little evidence of sedimentation or infilling of the river channel detected in recent river surveys (ABER, 2007). Sediment

can however be a major issue in the lower energy creeks where channels have become infilled with sand, such as Six Mile Swamp Creek in the Bungawalbin Catchment. Sediment transported from drains can also build mud flats and smother sea grass in the lower estuary. Shoaling in the lower estuary is determined by a balance between freshwater inflows and tidal range and shoals within the entrance are mostly stable other than reworking during major floods and some tidal movement (ABER, 2007).

Plate 24: Severe bank erosion and degraded riparian zone on the Richmond River near Casino

Bank erosion is prevalent in many areas within the estuary management zones. Bank erosion occurs mainly because of loss of vegetation in key riverbank areas where water velocities are high and banks scour, resulting in undercutting and bank slumping. Additionally, riparian areas can become susceptible to erosion as a result of trampling by stock (refer Section 7.7), vehicle access, boat wash and unlicensed access to the river (refer Section 7.10). The significance of these impacts varies according to the location along the river system. Large stretches of the Richmond River and its tributaries have been reported as being devoid of good quality riparian vegetation which in many instances coincides with areas of active bank erosion (WBM, 2006). Riparian vegetation is critical for maintaining bank stability and channel integrity as well as decreasing sediment run-off.

Predicted sea level rise due to climate change may increase erosion due to increased estuary water levels and the interaction of tidal waters with catchment floodwater. Climate change impacts are discussed in Section 7.3.

No.	Riparian Zone and Erosion Management Issues
I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.
I6	Unrestricted stock access causes vegetation damage and bank erosion
I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary
I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value

No.	Riparian Zone and Erosion Management Issues
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary (refer Section 7.10)
I29	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access (refer Section 7.10)
I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion
I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues

7.7.2 Management Objectives

Table 9 shows the relationship between issues, related values and management objectives.

Table 9: Relationship between Riparian Zone Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The estuary supports a number of rare and threatened communities • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community	I5 - Lack or poor condition of riparian vegetation increases bank instability and erosion. I6 - Unrestricted stock access causes vegetation damage and bank erosion I17 - Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary. I21 - Lack or poor condition of riparian vegetation compromises habitat connectivity and value I33 - Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, inundation of low lying ecosystems, habitat modification including landward migration of ecological communities and bank erosion I34 - Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	O6 - To protect and enhance the riparian zone O15 - To minimise risk to the health and safety of users of the estuary

7.7.3 Potential Management Options

Given the current degraded status of much of the riparian zone in the study area, the task of addressing this issue is a major challenge for the Richmond River. The establishment of suitable vegetation for riparian biodiversity corridors and natural vegetation for stabilisation of denuded banks would result in a significant reduction in bank erosion and sediment displacement while enhancing ecosystem values and improving water quality for the estuary as a whole.

Future planning controls and agricultural practices need to support better management of the riparian zone. Identification of existing Crown land parcels and Council reserves along foreshore areas and

better protection of these areas is a priority. Dedicating riparian buffer areas on streams and waterways of the estuary and encouraging farmers to enhance these buffers and employing best practice land management techniques are also potential options. Education of farmers, landowners and the community is required to demonstrate the value of riparian zones. The supply of long term fully funded extension services would be advantageous where possible to enable working relationships to be built over long time frames. The provision of funding incentives and labour assistance through existing funding avenues should continue to be offered to land owners to facilitate these actions (refer to Section 7.6 for further discussion on farm management).

To identify the extent of erosion risk within the estuary, predicted tidal inundation levels need to be determined as discussed in Section 7.3.3 as well as the interaction of tidal waters with catchment flows and the influence of sea level rise. Areas susceptible to erosion risk and the requirement for buffer zones, riparian vegetation management or other erosion mitigation measures can then be determined.

There is currently no coordinated process for riparian management across the study area. Currently, a number of riparian zone management projects are underway in the study area by a number of different stakeholders including Landcare groups and private landholders in association with government agencies. Richmond Landcare Inc. oversees many of the funded projects. These groups along with private landholder have made notable contributions to riparian vegetation improvements in the study area. Most of the work is carried out on a case by case basis where landholders or groups are willing and funding is available. These projects have been successful in many areas and their value should not be understated in improving the current state, however an overall plan for riparian rehabilitation presents many advantages over the current approach. Benefits include optimisation of works to achieve best outcomes, promotion of works at visible sites, continued support for funding based on an overriding plan. By identifying and prioritising riparian areas for rehabilitation, managers can assess the areas that will provide the greatest benefits for the effort expended or ‘best bang for buck’. Prioritisation can consider a number of factors including:

- Identification of high impact land use, where vegetated buffers will provide benefits in soil retention/interception and improvement of overland runoff, thus improving water quality;
- Identification and prioritisation of bank erosion areas that would benefit from riparian planting;
- The location of key habitats and enhancement of these areas through greater connectivity created by riparian restoration;
- Land ownership - Crown land or council owned land may be more successful options than privately owned land as demonstration sites; and
- The location of sites in terms of public visibility to promote activities and act as demonstration sites and to enhance aesthetic qualities of the estuary.

Preliminary work by Australian Wetlands (2010, refer Appendix 2) has described the riparian vegetation for the study area, however, this information is not currently in a form suitable to direct management action. Several further tasks are required including:

- Mapping of the existing presence and condition of vegetation across the study area;
- Mapping Crown Land and Council foreshore and riparian land;
- Identification and prioritisation of rehabilitation areas based on factors discussed above; and
- Identification of funding sources and responsible parties for management of areas.

Examples of sites suitable for rehabilitation of the riparian zone exist in all the management zones. In the Swan Bay, Bungawalbin and Kilgin/Buckendoon/Dungarubba management zones, potential demonstration sites are at Dungarubba Creek, Oakland Road and Woodburn on the opposite bank to

the main town. Good opportunities for revegetation exist around the mouth of Rocky Mouth Creek in Woodburn and with landholders along the creek.

No.	Riparian Zone and Erosion Management Options
22	Riparian buffer zone establishment (planning)
23	Identify priority riparian areas and rehabilitate
41	Assessment and mapping of tidal inundation extent including potential sea level rise

7.8 Vegetation Management

7.8.1 Issues

Conservation of existing vegetation

With the exception of the Bungawalbin Creek subcatchment and the Border Ranges, the majority of the Richmond catchment has been extensively cleared of native vegetation. Based on a range of broad vegetation mapping datasets provided by NSW NPWS (2005), WBM (2006) estimated that approximately 26% of the study area supports remnant or regrowth native vegetation and estuarine and freshwater wetland habitats, approximately 9% of the study area supports disturbed vegetation communities and habitats and 65% of the study area is cleared or developed land.

The effects of vegetation clearing were summarised by the EPS (WBM, 2006) as:

- Loss of vegetation and associated fauna species. Clearing of vegetation has reduced the biodiversity values of the Richmond River and its catchment;
- Fragmentation of habitats. Remnants within the study area have vegetation corridors forming linkages to other remnants outside the study area. The current long-term viability of these remnants to species that rely on vegetated “movement” corridors may be severely compromised by any further broad-scale disturbance. Past vegetation clearing has resulted in many remnants becoming isolated due to the lack of connecting corridors;
- Increase sediment and nutrient loads to the estuary; and
- Changes in morphological (erosion, accretion) processes within the estuary.

The EPS compiled available mapping of broad vegetation types within the catchment from a number of sources. The habitats and communities of conservation concern were identified by WBM (2006) as:

- Rare and threatened communities, as defined under the TSC Act, namely:
    - Coastal Saltmarsh;
    - Swamp Oak Floodplain Forest;
    - Swamp *Sclerophyll* Forest On Coastal Floodplains;
    - Freshwater Wetlands On Coastal Floodplains;
    - Littoral Rainforest;
    - Lowland Rainforest on Floodplains; and
    - Ripple-leaf Muttonwood (*Rapanea species* A Richmond River).

- Wetlands of conservation significance. SEPP 14 wetlands (4,964 ha) and Zone 7(a) Environmental Protection (Wetlands) or E2 (Environmental Conservation) under the new LEP instrument; and
- SEPP 26 Littoral rainforest (47.1 ha).

The above areas support habitats for a wide range of threatened flora and fauna species, as listed under Commonwealth and state legislation.

Some areas are protected under council reserves while some areas of private land are protected under conservation covenants such as the OEH Voluntary Conservation Agreement or the NSW Nature Conservation Trust (NCT) land covenants. The NRCMA also has five or ten year Landholder Management Agreements (LMA) and ten year Property Vegetation Plans (PVP). Large tracts of remaining vegetation are protected within National Parks or Nature Reserves in the study area. Other areas on private land remain unprotected within Council's planning schemes and the States reserve system. These areas were mapped by WBM (2006). Activities in the catchment are known or are likely to impact on floodplain and terrestrial vegetation and their fauna species. Inappropriate fire regimes, changed hydrology, poor water quality, weed invasion, stock damage and current-day clearing can all impact on ecological values.

Aquatic Weeds

Outbreaks of aquatic weeds are known to occur in several locations within the study area. These weeds can reduce the ecosystem values of open water for birds and fish. Aquatic weeds can cause diurnal fluctuations of dissolved oxygen and provide a source of organic matter for the production of MBOs (refer Section 7.5.1), which when mobilised by flood flows can completely deoxygenate the water column. Examples of Lily outbreaks in the Tuckean have been reported as linked to MBO formation.

No.	Vegetation Management Issues
I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment
Other related issues	
I5	Clearance or poor condition of riparian vegetation increases bank instability and erosion (refer Section 7.7)
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary (refer Section 7.10)

7.8.2 Management Objectives

Table 10 shows the relationship between vegetation management issues, related values and management objectives.

Table 10: Relationship between Vegetation Management Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function	I22 - Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	O10 - To protect and enhance the biodiversity values of the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment

7.8.3 Potential Management Options

Conservation of existing vegetation

Protection of existing native vegetative communities, particularly threatened communities and floodplain habitats is an on-going issue for management of overall ecosystem health. Rehabilitation of degraded habitats, particularly riparian and floodplain communities is required, focussing on improving ecological condition (e.g. weed control) and connectivity (e.g. protection and replanting) throughout the catchment. In order to identify areas for targeted improvement programs, further investigations is required involving:

- Review of mapping of high conservation value habitat and existing corridors (NPWS, 2005):
- Prioritise threatened species habitats and EECs on the study area floodplain for conservation, using currently available information; and
- Development of a prioritised list of land use planning changes to adequately protect important habitats considering a number of factors including mapping as above and landowner willingness, mitigation of water quality issues etc.

Aquatic Weed Management

Management of aquatic weeds is currently carried out by RRCC in the study area by mechanical harvesting and chemical controls. Much of this work is carried out as part of asset maintenance works, however environmental benefits, such as improved water quality and reducing factors in MBO formation are also acknowledged. In addition to routine aquatic weed management, a more holistic approach to management should be considered by addressing ecological issues that contribute to aquatic weeds such as improving tidal flushing, restoring a more natural hydrology, and increasing riparian planting for shade and as a nutrient buffer.

Plate 25: Aquatic weed removal at Mynumai Lagoon before (left) and after (right)

No.	Vegetation Management Options
24	Aquatic weed management
25	Retain, rehabilitate and conserve existing native floodplain vegetation

7.9 Education

7.9.1 Issues

Community education/involvement and capacity building is essential to the success of other management initiatives. In this way, education is relevant to all estuary management issues and the achievement of objectives.

It will be important to raise public awareness of the values and sustainable use of the Richmond River estuary through targeted community education programs. The issues are:

- Opinions and perceptions are sometimes based on old or inaccurate information;
- Information is not always available to the people best placed to make a difference (e.g. farmers);
- Social acceptability of management options will increase as community understanding of the issue increases;
- Conflict between users can be alleviated with the provision of objective information; and
- Community satisfaction with estuary management is sometimes based on perception rather than fact (e.g. perception of need for dredging).

7.9.2 Potential Management Options

Education programs are a major opportunity to improve estuary management by giving the community an understanding of the true impacts of activities.

A number of existing education programs should be supported through the estuary management planning process. These include:

- DPI (Agriculture) landholder education programs e.g. best practice land management;
- Rous Water catchment management initiatives;
- Northern Rivers CMA programs including community capacity building;
- Council initiatives e.g. waste management education centres, water education programs, stormwater management programs and state of the environment reporting, biodiversity programs; and
- OEH education resources.

RRCC in partnership with Ballina, Lismore and Richmond Valley Councils, OEH and the Northern Rivers CMA has been developing a program to promote the sustainable use of the Richmond River Estuary ("The Richmond River Estuary - Our Community's Natural Asset"). The program is jointly funded by the local and state governments and seeks to find out what the community knows of estuaries and actions that can help reduce potential and actual damage. Signs have been erected along the estuary to highlight some issues identified in a recent survey that the community have indicated that they are concerned about. Results of the survey will be used to develop a range of education strategies and programs which will raise the community's and visitors' understanding of the environmental, social and economic significance of the estuary system and ways to work towards the long term sustainability of the Richmond. This incorporates the Richmond and Brunswick catchment model (see Appendix 1).

Stephen Fletcher & Associates (2006), in its review of the "Richmond River Estuary – Our Community's Natural Asset" community education project, recommended that future education programs include:

- A regular column in local newspapers and regular radio segments discussing key issues, current initiatives and tips for residents to minimise impacts;
- High school education packages focussing on local ecology and biodiversity, cause and effect relationships and estuary health, sustainable participation and field work.
- Signage highlighting the estuary, its significance and tips to minimise impacts; and
- Brochures on estuary management issues.

It will be important to support education projects or programs that develop or widen the community's knowledge of, skills and commitment to protecting the Richmond River Estuary. This should include all aspects of estuary management to ensure public use of the estuary is undertaken sustainably.

No.	Education Management Options
37	Estuary-wide community education and consultation program

7.10 Waterway Usage

7.10.1 Issues

The Richmond River estuary is highly valued for various forms of recreational use, and these pursuits constitute the dominant use of the estuary. Commercial boats also utilise the estuary for fishing, oystering and tourism activities which are also important in the region. Providing appropriate boating facilities to meet growing demand (see GHD, 2005) ensuring cooperative use of the waterway between various forms of recreational and commercial users while protecting the ecological values of the estuary are key challenges for successful holistic management of the estuary.

Recreational use of the Richmond River estuary is varied and includes activities such as boating, swimming, fishing, surfing, water-skiing and wake-boarding, jet skiing and passive recreation. Consultation work carried out as part of the EPS (WBM, 2006) indicated that the community considers the value of boating in the estuary to be high with fishing from boats being the top recreational usage of the estuary (WBM, 2006). The EPS includes mapping of broad usage zones for the estuary. Generally the high use primary and secondary contact activities occur in the lower estuary with less intensive waterway usage upstream.

Dredging

Extensive navigational dredging of the lower Richmond River, particularly the entrance area, has occurred since 1883. Before 1911, dredging operations in the lower Richmond River were largely associated with the entrance training works and a navigation channel through the entrance and past the town shoal. Much of the dredged material was used for landfill at Ballina and hence lost to the active beach system. Between 1911 and 1974 periodic dredging was undertaken across the entrance bar and in other locations further up the lower estuary where increased depths were required for navigation purposes. Much of this material was side cast onto the shore or used for land reclamation at Ballina or on Pimlico or Cabbage Tree Islands. Since 1974 (cessation of coastal entrance dredging in NSW) dredging has occurred in North Creek for oyster leases and the extraction of 200,000m^3 in the early 1990s for bridge abutments and associated road works (WBM, 2006).

Dredging is periodically raised by the community as a measure to primarily address navigational issues in the lower estuary. The river entrance bar in particular, poses a hazard for vessels under adverse swell and tide conditions, and several small recreational boats have been overturned when attempting crossings under such conditions. The depth of the bar also poses problems for deep draft vessels even under ideal conditions, with depths of around 3.5 metres at low tide. A shoal within entrance upstream of the Coast Guard tower presents a secondary restriction at a depth of approximately 2.5m. These bars have maintained their current depth for a number of years without dredging (GHD, 2005). Such depths are regarded as adequate for recreational boating and current commercial activities (BSC, 2007) but limiting for larger vessels and some yachts that may wish to use the estuary. There is community support for increased marina facilities at Ballina (GHD, 2005) and further study in this regard should consider navigation constraints within the estuary.

Dredging of the bar or entrance shoals would only offer temporary depth increases as sand from the longshore transport system would quickly infill these areas (GHD, 2005) and may contribute to increased variability in bar location and increase risks for boat owners relying on deeper entrance conditions to overcome adverse crossing conditions. Other options such as modification to the entrance training walls have also been considered but are likely to result in similar bar conditions as experienced with the current arrangement (BSC, 2007). GHD (2005) reports that there is strong community support to ‘fix the Bar’ however NSW Waterways have indicated that once-off dredging or training wall extension would not provide a permanent solution.

The mouth of Emigrant Creek at the confluence with the Richmond River has also been raised as an area requiring dredging to maintain navigability at this location. There is a small marine industrial precinct located within the estuarine reaches of Emigrant Creek containing a slipway with hardstand facilities, industrial sheds and private slips as well as numerous channel mooring points. Access for deep drafted vessels is limited to high tides only with shoaling evident at the Creek mouth and some locations upstream.

Dredging has significant impacts on benthic communities through direct disturbance as well as through issues associated with sedimentation and turbidity plumes. NSW Fisheries (now Industry & Investment) have indicated that the presence of seagrasses, an important fisheries habitat at numerous locations, including the entrance to Emigrant Creek and in North Creek means that dredging is unlikely to be approved to increase navigability in these locations.

Sand Extraction

Dredging of sand from the lower estuary has also been raised as a potential commercial venture to capitalise on this frequently renewed resource. No assessment of the viability of this concept has been undertaken to date, although the potential environmental impacts, including effects on longshore transport of sand, and coastal beach erosion risks to the north of the river could be significant and would need substantial investigation. Of note is the North Creek Flood Study, which identified that sand extraction in North Creek would be likely to increase tidal amplitude and therefore the risk of flooding from tidal surge in this area.

Currently, one sand extraction operator (Boral) is permitted to extract sand from more upstream reaches of the estuary. Sand is extracted from the freshwater reaches of the river under a licence with the Department of Lands to extract up to around 37,000m^3 of material of year. The extraction occurs over a large area of the estuary from near Woodburn to up past Coraki and extensive portions of the Wilsons River from Coraki to up past Lismore. This operation has resulted in several complaints, which have been followed up by the Department of Lands and has resulted in modifications to the operating licence (WBM, 2006). It appears that these actions have solved this issue.

Boating Facilities

Recreational boating forms a vital component of the tourism sector of the Richmond River communities and is a significant lifestyle activity enjoyed by a large proportion of its residents. Many of the communities, particularly those in coastal areas, are reliant on tourism to drive their local economies. Availability of suitable river access points and appropriate and complimentary marine infrastructure is critical to the enjoyment of recreation boating in the estuary. The quality of this infrastructure is important in attracting and retaining visitors to the communities along the Richmond River as a destination of choice.

The Lower Richmond Recreational Boating Study was completed in 2005 (GHD, 2005). The study reported that current boating facilities in the lower estuary were inadequate to provide the expected level of service for local and visiting boats. Issues discussed centred on the upgrade of existing facilities and provided recommendations for the provision of new facilities. Ballina Shire Council is progressing with the implementation of aspects of the plan to improve recreational boating in the lower estuary. One of the major issues was the lack of pump-out facilities for boats in Ballina Shire. Where boats do not access the ocean to empty holding tanks, options for disposal of raw sewage are very limited.

Usage Conflicts

During the community consultation phase of the Draft EMS, the concern among the community for the potential for conflicts between different waterway uses was raised. Currently, there is generally not a lot of conflict between users, however as population increases and waterway sports expand and

diversify further, the potential for future usage conflicts is also increasing. NSW Maritime has identified that in addition to the traditional pursuits of sailing and boating, other waterway uses on the Richmond are now becoming popular (including canoeing, jet skiing, water skiing and the use of tubes towed behind powerboats) in the lower estuary in the urban areas of Ballina Island (WBM, 2006). Noise and safety are a key consideration for these activities. Over the past several years there has also been an increase in wakeboarding activities on the river which generates waves behind a boat which can cause nuisance issues for other users and is also known to cause significant bank erosion due to the generation of 'wake' (refer discussion of bank erosion below). Kite surfing is also a fast-growing sport and has potential as an emerging issue for safety concerns in the estuary. Anecdotal evidence suggests human activities (including boat access and dogs) are harming sea grasses and shorebird habitat in Mobbs Bay.

Public foreshore access

Public access to estuarine foreshore areas is highly valued by the community. One of the aims of the NSW Coastal Policy is to ensure the provision of public access to foreshores where feasible and environmentally sustainable. Public safety is a primary consideration when planning access facilities.

The EPS (WBM, 2006) identified existing access facilities including waterfront licences (for jetties, wharves, boatsheds, boat ramps, pontoons and slipways), boat harbours, mooring areas, parks and reserves and the Ballina Marine Industrial Precinct. Informal access to the foreshore causes bank erosion and trampling of vegetation which are likely to be exacerbated by the potential climate change impacts of sea level rise and increased storminess.

Current land-based foreshore access issues were identified along the riverfront in Ballina Island and other areas including Lismore where the presence of existing foreshore developments restricts public access. BSC is endeavouring to provide public access pathways adjacent to the lower Richmond River Estuary.

Licensing of waterfront structures

Waterfront structures (e.g. jetties, boat ramps and slipways) over lands below the high water mark of foreshore properties are generally located on Crown land and occupation of such lands must be authorised. Structures of this nature are called Crown Licence Points. WBM (2006) reported that 188 Crown Licence Points were registered on the Richmond River estuary and most were structures including jetties, pontoons, ramps and slipways. During development of the EPS (WBM, 2006), it was reported that there were currently a number of unlicensed waterfront structures in the estuary and there was concern about public safety and environmental damage (erosion, damage to sensitive vegetation etc.) as a result of poorly constructed or located structures. DPI and Crown Lands are the process of completing a program of assessing waterfront structures and reviewing licences to address this issue.

Bank erosion

Boat wash striking the river banks can cause rapid and severe erosion leading to a range of environmental problems. Such problems may include the loss of riverfront property, water quality degradation, loss or destabilisation of native trees and the destruction of habitat and aquatic plants and animals.

There are areas of active bank erosion throughout the lower Richmond estuary, however many are protected by bank protection works consisting predominantly of loose rock protection as far upstream as Wardell (WBM, 2006). Locations which are being impacted by boat wash are sections of Emigrant Creek and some sections of the North Creek Canal (WBM, 2006). Speed limits have been set by NSW Maritime for these areas, however the effectiveness of this measure in controlling speed and subsequent boat wash and bank erosion is currently unknown. Active bank erosion is evident in the

upper estuary, however, the principal causes for this were likely to be riparian vegetation clearing and stock trampling of banks, rather than from boat wash.

Tidal inundation and flood events can also increase bank erosion and impact riparian vegetation as well as property and infrastructure.

Damage to seagrass beds, salt marsh and mangrove communities

Estuarine vegetation such as seagrass, saltmarsh and mangrove communities provide a number of important ecological functions for the estuary including nursery and feeding grounds for fish and habitat for a range of other native fauna and flora including a number of threatened species. While large mangrove areas exist in the estuary, there are limited numbers of seagrass beds and saltmarsh areas present in the Richmond River (WBM, 2006). These areas of sensitive estuarine vegetation may be affected by boating, recreational users and unlicensed access points to the estuary due to propeller and anchor damage, boat wash and disturbance from built structures and vehicle access. The EPS reported that all areas of known seagrass in the Richmond can potentially be impacted by boating activities and areas near the confluence of Emigrant Creek and the Richmond River, Mobbs Bay and in North Creek (between the Missingham Bridge and Prospect Bridge) are most likely to be susceptible to these impacts. Within the estuary, most of the existing saltmarsh areas are protected behind fringing mangrove communities. The loss of fringing mangroves exposes the saltmarsh communities to boat wash, human access etc. and may create conditions that affect their ability to habitat these areas. WBM (2006) reported that while there was some physical controls (buoys) located to protect seagrass areas, the effectiveness of these measures was unknown and there was generally a lack of physical controls to limit potential impacts to mangrove and saltmarsh areas.

No.	Waterway Usage Issues
I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access
I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary
I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary
I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing
I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats
I29	Illegal waterfront structures allow access to estuary posing risks to public safety
I30	Siltation is affecting navigation and/or safety in the lower river
I31	Lack of provision of appropriate public access to foreshore

7.10.2 Management Objectives

Table 11 shows the relationship between waterway usage issues, related values and management objectives.

Table 11: Relationship between Estuary Usage Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • Scenic amenity is valued highly by the local community and visitors • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • The estuary supports a number of rare and threatened communities • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • The riparian zone provides significant protection to estuary water quality • Good water quality is highly valued by the community	I8 - Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access I9 - Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary I23 - Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary I27 - Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing I28 - Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats I29 - Illegal waterfront structures allow access to estuary posing risks to public safety I30 - Siltation is affecting navigation and/or safety in the lower river I31 - Lack of provision of appropriate public access to foreshore	O1 - To encourage economically viable and environmentally sustainable land use practices in the catchment O6 - To protect and enhance the riparian zone O10 - To protect and enhance the biodiversity values of the estuary O11 - To provide for increased use of the estuary whilst minimising environmental impact and conflict between users O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain O15 - To minimise risk to the health and safety of users of the estuary

7.10.3 Potential Management Options

Dredging

Dredging of the Richmond River bar and the upstream shoals as well as other areas in the lower estuary such as North Creek and Emigrant has been suggested as a potential solution to navigation risks in these areas and increasing the potential for larger vessels to utilise the estuary. Whilst no detailed assessment on the feasibility or impacts associated with dredging has been undertaken, preliminary comments from NSW Maritime has indicated that irregular dredging would not provide successful alleviation of navigation issues in the long term and therefore any commitment to dredging in the lower estuary would need to be as part of a continued program probably coupled with cost recovery through sales of the extracted sand. At present there does not appear to be sufficient requirement for such a program and the combined impacts on benthic communities, water quality and the potential northward beach erosion present significant hurdles. A preliminary study into the feasibility of dredging operations, including associated commercial opportunities should only be undertaken if further assessment of marine facilities expansion in Ballina is to be undertaken.

Boating Facilities

The Lower Richmond Recreational Boating Study (GHD, 2005) developed strategies to address the current and future needs and requirements of recreational boating within the lower Richmond River estuary, including a program of works and actions focussing in the provision of boating infrastructure. BSC is progressing with the implementation of aspects of the plan to improve recreational boating in the lower estuary. Recommendations of the Boating Study should be considered in the management of boating facilities in the Richmond.

Usage Conflicts

NSW Maritime currently controls waterway usage for the purposes of boating. The NSW Maritime boating maps provide details of navigational controls, speed restrictions and other warnings for the Richmond River estuary. NSW Maritime also has a policing role on the waterway and responds to various complaints about nuisance activities on the water and conflicts between different uses. While the control mechanisms in place by NSW Maritime are currently addressing issues as required, there are emerging issues for the Richmond estuary and particularly the lower estuary. These issues are associated with a fast-growing population and expanding recreational use of the estuary and the need for strategic planning for future management. While usage conflicts are considered to be very minor occurrences at present, there is concern among the community about potential for future problems. Usage zones are utilised in other estuaries to separate various uses and locate certain uses in appropriate areas for example away from sensitive vegetation. Appropriate planning controls may offer a mechanism to reduce social and environmental impacts in the future.

Public Foreshore Access

The economic, social, environmental and cultural values, such as scenic amenity, fishing and aquaculture, tourism and recreational activities rely on the ability to access the waterway and foreshore areas. The desire for continuing and undiminished public access needs to be balanced with the ecological values of the estuary such as the diverse habitats, ecological importance of the riparian zone and water quality. A strategic plan for use of the Richmond River Estuary is required to address the identified issues associated with foreshore access and plan for current and future requirements. Potential impacts on access arrangements (e.g. erosion, accretion, tidal inundation) should be identified through the coastal hazard assessment of estuary erosion and tidal inundation (refer Section 7.3.3).

Licensing of waterfront structures

A review of waterfront structures licensing has been recently undertaken by DPI - Fisheries and Crown Lands (Marcus Riches, Fisheries Regional Manager, pers. comm). The review has provided an assessment of the current licensing and policing of waterfront structures. One of the outcomes of the review was mapping of colour coded zones for the estuary to assign areas where certain types of structures are permitted or restricted under existing policy. This review is currently being reported and should be available in the coming months. Recommendations of the review should be considered in future estuary management.

Bank erosion

Bank erosion from boat wash is considered to be largely controlled in the lower estuary through existing protection works, which extend from the river mouth to Wardell. While bank erosion is considered to be a significant issue impacting on estuarine health, most of the bank erosion exists in the upper reaches and other factors such as high velocity flood flows, poor riparian cover and condition and stock access are considered to be the primary causes, with boat wash as a minor or negligible factor. The exception noted in the EPS (WBM, 2006) was areas of active bank erosion in Emigrant Creek and North Creek, where boat wash was implicated as the primary cause. While speed limits are currently set in these areas to minimise the impact of boat wash on erosion, it is not clear whether this measure is enough to solve bank erosion issues. Further assessment of boat passage areas impacted by erosion is necessary to assess the current status of bank erosion and the adequacy of current speed limits in managing this issue.

Further assessment of erosion caused by tidal waters and flood events is required to determine the impacts to property, infrastructure and riparian vegetation. This should also consider sea level rise scenarios (refer Section 7.3).

Damage to seagrass beds, salt marsh and mangrove communities

There may be a need for further physical controls (e.g. signage, warnings) that limit potential impacts to sensitive estuarine vegetation, specifically seagrass, mangrove and saltmarsh areas.

No.	Waterway Usage Management Options
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary

7.11 Wastewater Management

7.11.1 Issues

Eight STPs discharge to the Richmond River within the tidal limit (Casino, South Lismore, East Lismore, Alstonville, Ballina, Wardell, Rileys Hill and Coraki STPs). Sewerage systems (including STPs and overflow structures) are regulated by OEH-EPRG through Environment Protection Licences (under the Protection of the Environment Operations Act, 1997) held by the respective Councils. Where required by the EPRG, the licences include Pollution Reduction Programs to improve the performance of the STPs. The STPs are generally meeting licence conditions although an upgrade of the treatment process is planned for Ballina STP including a new membrane bioreactor, UV disinfecting for all discharges, chlorination, and potential reuse for vegetation regeneration and open space in urban areas.

The impact of the STPs on estuary water quality depends on discharge flows and loads of pollutants such as nutrients and faecal coliforms. Pollutant loads from urban inputs become relatively more important to water quality during the dry season when catchment inputs are low. The EPS (WBM, 2006) identified STP input during these dry times as a potential risk to water quality although a comprehensive assessment of risk across all STPs influencing the estuary has not been conducted to date. During rainfall events, nutrient concentrations within the estuary increase by several times as a result of diffuse loads from the catchment (WBM, 2006). The EPS found that the impact of nutrient loads from urban runoff and STPs on water quality was negligible in comparison to the impact of diffuse loads.

Most urban areas within the Richmond River catchment are served by a reticulated sewerage system. Rural and rural residential areas without reticulated sewerage have on-site systems including composting toilets, septic systems, aerated wastewater systems, pump-out systems and grey water treatment systems. The design, installation and operation of domestic on–site sewage management systems are regulated under the Local Government Act 1993. The Councils have implemented on-site sewage and wastewater management strategies in accordance with the Local Government (Approvals) Regulation 1999 including audit and inspection of on-site systems. However, it is the responsibility of the owner or occupier of the premises that has an on–site wastewater system to ensure that on–site systems are designed, installed and managed so that pollution of groundwater or surface waters does not occur, and there is no risk to public health, safety and the environment from the operation of an on–site sewage management system.

Councils undertake random inspections annually as part of the audit program to identify failing systems. Annual inspections of on-site sewage and wastewater systems by LCC in 2007 revealed that 33% of systems inspected failed to meet operational criteria (Hydrosphere Consulting, 2010). Council backlog sewer programs have identified areas to be connected to the Council sewerage system based on the risks to public health, aquatic ecosystems, groundwater supplies and contamination of shellfish areas and inappropriate soils, lot size and topographic conditions. On-site wastewater systems in North Woodburn are known to cause public and environmental health impacts. A survey conducted by LCC's Environmental Health section indicated that 50% of the systems are failing due to poor soil permeability, small lot sizes and high rainfall. The systems do not comply with the on-site sewerage management strategy due to the close proximity to the Richmond River, flood liability and inadequate size of disposal area. LCC is planning to provide a reticulated sewerage system to North Woodburn with connection to the RVC Evans Head/Woodburn sewerage system.

BSC has identified 150 priority lots for connection to Councils sewerage system including North Creek Road. Council has also commenced a program of registration of all on-site sewerage management systems in the shire. RVC plans to provide a reticulated sewerage system to Broadwater by 2013.

No.	Wastewater Management Issues
I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown
I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear

7.11.2 Management Objectives

Table 12 shows the relationship between wastewater management issues, related values and management objectives.

Table 12: Relationship between Wastewater Management Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • Good water quality is highly valued by the community	I14 - STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown I15 - Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown. I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	O5 - To reduce pollutant loads to the estuary O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.11.3 Potential Management Options

Environment protection licences are the central means to control the localised, cumulative and acute impacts of pollution in NSW although they are only applicable to point sources. Responsibility for management of STP discharges remains with the local councils, regulated by the OEH-EPRG under the Protection of the Environment Operations Act, 1997. This includes options for reuse of treated wastewater.

Responsibility for performance of on-site sewage systems remains with the property owner, regulated by the local councils under the Local Government Act, 1993.

Reduction of point source pollution such as nutrients and faecal coliforms from sewerage systems is consistent with the aims of the estuary management program. As these activities are managed and regulated by existing administrative processes, it is proposed that these activities continue outside but complimentary to the CZMP process, while ensuring consistency with the CZMP.

No.	Wastewater Management Options
19	Upgrade / augment STPs and other sewerage infrastructure where required
20	Wastewater Reuse
40	Ongoing on-site sewerage management inspections and improvements

7.12 Urban Runoff

7.12.1 Issues

Urbanisation has affected estuarine processes through:

- Changes to the hydrologic characteristics (catchment hardening) of lands making them drain more quickly, partly due to the increased imperviousness, i.e. road, roofs, etc;
- The use of hydraulically efficient stormwater pipe systems which remove stormwater to the waterway more quickly; and
- Changing the quality of stormwater runoff due to the influence of fertilisers, cars, lawnmowers, domestic animals, etc.

Stormwater from urban areas can often discharge significant loads of pollutants to receiving water bodies. These pollutants include litter, nutrients, sediment, oxygen-depleting substances and hydrocarbons, which are transported from the site by urban runoff or stormwater. Urban runoff has particularly been found to impact seagrasses and benthic communities within the Richmond River (WBM, 2006).

BSC and the community have identified urban stormwater as a significant issue with respect to the estuary. Many of the water quality complaints made to BSC relate to urban stormwater such as poor erosion control on building sites and vehicle wash-water discharged to drains. In a community consultation process undertaken for the Shaws Bay Estuary Management Plan, 45% of the 49 respondents identified runoff from the largely urban catchment discharging into the bay through the stormwater drains as a major issue for the health of the Bay (WBM, 2006).

A large proportion of people within the study area resides in, works or engages in recreation within urban centres. Some urban centres within the estuary are also located adjacent to water bodies used by residents, visitors and industries such as oyster leases dependent on good estuarine water quality. Any water quality impacts due to urban stormwater or practices within the urban environment that may contribute to poor urban stormwater quality would subsequently be more likely to be observed by people within these urban areas relative to those occurring in rural areas not frequented by the public (eg. acidic runoff discharge from drainage channels). The EPS (WBM, 2006) found that the impact of urban stormwater to overall estuarine water quality is a significant issue to the public and councils. The importance of managing urban stormwater will also become increasingly important as the extent of urban development increases to accommodate the increase in populations within the study area.

No.	Urban Runoff Issues
I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary
I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear

7.12.2 Management Objectives

Table 13 shows the relationship between urban runoff issues, related values and management objectives.

Table 13: Relationship between Urban Runoff Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River catchment supports a wide range of land uses which are important contributors to the local and regional economy • Commercial fishing and oyster aquaculture contribute to the local and regional economy • The freshwater sections of the estuary are a valuable source of water for the agricultural industry and also provide potable town water supply from the tidal pool upstream of Lismore • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities • The Richmond River Estuary and wetlands provide a diversity of habitats for a range of terrestrial and aquatic species • Estuarine wetlands including mangroves, saltmarsh and seagrass areas provide an important role in healthy ecosystem function • Good water quality is highly valued by the community	I13 - Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary I16 - Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	O5 - To reduce pollutant loads to the estuary O15 - To minimise risk to the health and safety of users of the estuary O13 - To protect and enhance visual amenity/ aesthetic appeal of the estuary O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement

7.12.3 Potential Management Options

The EPS (WBM, 2006) noted examples of poor urban development which are likely to have resulted in the loss of significant habitat areas and due to their proximity to the estuary are likely to be contributing pollutants to the waterways. There are many opportunities for retrofitting stormwater/water quality controls to existing urban developments to address impacts exist and these should be investigated and prioritised. Any future developments in the study area, in particular new urban subdivisions (identified by Councils in their urban land release areas) should apply a holistic management approach to the protection of stormwater and water quality and the appropriate management of existing vegetative communities. This should include:

- Management of stormwater to ensure no significant risk to public health, property and the environment;
- Reduction in stormwater volume and improved quality of stormwater entering the estuary; and
- Sustainable and affordable reuse of stormwater.

Water Sensitive Urban Design differs from conventional conveyance based management methods as it takes an integrated approach to the management of stormwater quality and quantity. It seeks to incorporate sound stormwater management principles into the design of the development during the planning stages to minimise the need for “end of pipe solutions”. Ideally, it also examines the total water cycle for the development and includes provision for water harvesting and water reuse.

The linkages between day-to-day activities and the health of the estuary, such as the impact of stormwater runoff on water quality in the estuary are not well understood. A key component of any

stormwater management program is education on the impacts of urban runoff and potential improvements.

All councils within the study area are actively involved in the management of urban stormwater through a variety of projects, programs and policies including Stormwater Management Plans and Development Control Plans. This includes water sensitive urban design requirements, gross pollutant traps, education programs, drain mapping and more stringent requirements such as 'no-net worsening' for new urban developments. For example, BSC has installed stormwater filters around the Shaws Bay subdivision and at the lookout in East Ballina to minimise the impact of stormwater pollution on Shaws Bay and surrounding waterways. Filters are placed inside stormwater drains to catch pollutants such as soil, garden waste and cigarette butts.

The state Government BASIX program incorprates requirements for rainwater detention and reuse as a requirement for all new developments.

The Local Government Act provide councils with the ability to raise additional funds for stormwater management services outside traditional funding sources. These additional funds (the stormwater charge) can be spent on urgent works to improve stormwater treatment and infrastructure, to improve the quality of stormwater that is returned to the waterways. The stormwater charge only relates to urban developed land within a town or village to which Council provides stormwater services.

The reduction of urban pollution such as nutrients and faecal coliforms is consistent with the aims of the estuary management program. As these activities are managed and regulated by existing Council services, it is proposed that these activities continue outside but complimentary to the CZMP process, while ensuring consistency with the CZMP.

No.	Urban Runoff Management Options
16	Stormwater education
17	Water Sensitive (Urban) Design for new developments
18	Retrofit GPTs and other stormwater improvement devices

7.13 Cultural Heritage

7.13.1 Issues

The Richmond River estuary has spiritual and cultural significance for local communities. Both European and Aboriginal heritage sites and items exist in and around the estuary and their recognition and protection are important to the local community.

The traditional owners and custodians of the study area are the Bundjalung and Widjabul people. There are currently a number of Native Title Claims covering approximately 90% of the study area, currently being assessed (claims apply to land other than freehold land such as Crown Land and leasehold lands). Given the long period of Aboriginal use of the land there are numerous sites around the Richmond River estuary that are of Aboriginal heritage significance (e.g. art sites, camp sites, middens, fishing and hunting areas, caves and rock shelters, burial sites, mythological sites and scarred trees).

The Richmond River estuary also contains a wide variety of European cultural heritage items due to the rapid changes in key industries such as forestry and agriculture and the associated transportation networks development to support the industries, i.e. shipping and then rail. There are many listed heritage items, which occur around the urban centres, e.g. heritage buildings.

All levels of Government maintain registers of important sites, which are then afforded varying levels of protection under current legislation. During the community consultation phase of this study, the issue was raised that there were a number of sites of Aboriginal cultural heritage significance in the Richmond area that were currently not registered with relevant authorities and therefore there was concern about the on-going protection of sites.

No.	Cultural Heritage Issues
I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development

7.13.2 Management Objectives

Table 14 shows the relationship between Cultural Heritage issues, related values and management objectives.

Table 14: Relationship between Cultural Heritage Values, Issues and Objectives

Values	Issues	Objectives
• The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits	I32 - Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	O12 - To protect the cultural heritage values of the estuary

7.13.3 Potential Management Options

The protection of specific sites and locations of significance is already managed through various pieces of State Government legislation. The principle laws, which deal with Aboriginal heritage, are (refer Appendix 1):

- National Parks and Wildlife Act 1974 – This Act provides statutory protection for all Aboriginal objects and places in NSW. Areas are gazetted as Aboriginal places if the Minister is satisfied that there is enough evidence to show the area is, or was, of special significance to Aboriginal culture;
- Heritage Act 1977 – This Act protects the State's natural and cultural heritage. Aboriginal places or objects that are recognised as having high cultural value are listed on the State Heritage Register; and
- Environmental Planning and Assessment Act 1979 – This Act provides protection by considering impacts on Aboriginal heritage in land use and planning decisions. The three main areas are:
    - Planning instruments allow particular uses for land and specify constraints. Aboriginal heritage is a value which should be assessed when determining land use;
    - Section 79C of the Act lists matters which must be considered before development approval is granted. Aboriginal Heritage is one of the issues considered under the terms of Section 79C; and

- State government agencies act as the determining authority on the environmental impacts of proposed activities and must consider a variety of community and cultural factors, including Aboriginal heritage, in their decisions.

Existing State Government legislation is used to protect listed sites within the study area. There is recognition that further work is required to identify, assess and register remaining sites within the Richmond River catchment. There are ongoing studies underway which aim to improve the Aboriginal heritage listings within the Richmond River catchment and ensure their protection under legislation. The process requires extensive consultation and is likely to be on-going.

It may be appropriate in some instances to develop cultural site management plans for specific sites. The aim of these plans would be very site specific based on the requirements for management. At some sites it may be necessary to exclude access completely to protect cultural values, while at others, it may be acceptable to provide signage and create an educational experience for the broader public. Plans would need to be developed in close consultation with the local Aboriginal community and ensure all relevant groups are consulted. Any recommendations of this Draft EMS need to recognise the importance of both European and Aboriginal cultural heritage items and take their appropriate management into consideration when formulating management strategies for the estuary. Appropriate actions to protect and promote the cultural and heritage environment in the coastal zone, including responses to threats from projected sea level rise need to be incorporated in the CZMP in accordance with the APEC principles (Aboriginal People, the Environment and Conservation, DECC, 2008).

No.	Cultural Heritage Management Options
35	Identification and recording of cultural sites available to council planners
36	Cultural Site management plans

7.14 Fisheries and Aquaculture Management

7.14.1 Issues

Fisheries resources are an important value of the Richmond River estuary. Like water quality, there is general community perception that the state of the estuary's fish health and productivity is a key indicator of overall estuary health. Similarly, oyster productivity and saleability is regarded as being directly linked to estuary health. The estuary is well known as a recreational fishing hotspot and supports a range of commercial fishing activities.

Wild fisheries - a limited resource

It is generally accepted that that fish stocks have declined since the 'good old days' and it is recognised that wild fish stocks are a resource requiring active management to ensure sustainable harvests are achievable. Whether or not fish stocks are continuing to decline in the Richmond River estuary is difficult to determine. Some evidence indicates that fish stocks remain under pressure, for instance the Estuary General Fisheries Environmental Impact Statement (EIS, NSW Fisheries, 2003) notes that reported catch rates are not declining over time, however this is prefaced with the fact that fishing effectiveness is generally increasing and this factor is not readily incorporated into catch per unit effort statistics. WBM (2006) notes that both commercial fishing effort and associated catches are declining (Figure 38).

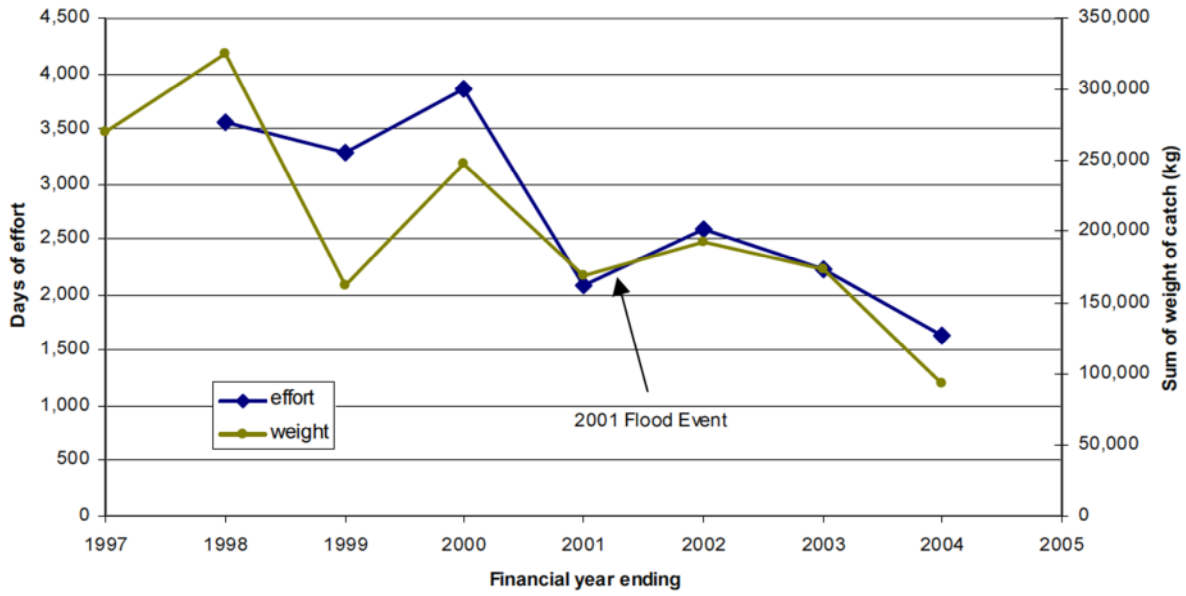


Figure 38: Declining commercial fishing effort and combined weight of catch

Source: WBM, 2006

There is also a view that the quality of catches in the recreational sector is improving, with such improvements being attributed to more stringent fisheries management and better technology. Regardless of the real trend in fish abundance, there is general community concern about fish stocks in the estuary and desire to ensure that recreational and commercial fisheries are preserved on a sustainable basis into the future.

Causes of decline in fish stocks

The factors implicated in the decline of fish stocks are reasonably well understood at a general level, however the key causes and the relative degree to which they influence fishing in the Richmond River estuary is not known. Given the migratory nature of many fish between estuaries, impacts in other estuaries as well as fishing effort along the coastline also have an impact on the Richmond River estuary fishery. Conversely the health of the Richmond estuary will impact on other estuaries. The importance placed on the value of the estuary fishery to the community dictates that on-going management action to address all the pressures on fish stocks is warranted.

Key considerations are:

- Habitat availability is a key factor in controlling fish populations in the estuary. The nursery value of estuaries for many species is well known and the degradation or complete removal of important habitats is as a major factor in fisheries management as loss of habitat can lead to fewer fish to share amongst all stakeholders;
- The presence of instream barriers such as weirs, floodgates and culverts in the catchment interrupt fish migration and dispersal within the catchment. These migrations are often essential for fish to complete their life cycle and the productivity of the catchment as a whole is reduced when effective fish passage is not available between downstream and upstream habitats;
- Poor water quality has a range of effects on fish populations. The most visible effect is evident in the large fish kills such as those experienced in the Richmond River estuary in 2001 and 2008. Fish kills are attributed to drainage from disturbed ASS catchments as well as the release of large volumes of black (deoxygenated) water from backswamp floodplain areas following summer floods (refer Section 7.5.1). Red Spot Disease (EUS) in fish is a chronic effect of acidified waters. More chronic effects of water quality degradation include effects on

fish stocks through restricting fish movement or habitat use in unfavourable areas, reduction on productivity and influences on the food chain and productivity; and

- The impact of overfishing can be dramatic as evidenced by the collapse of many fisheries throughout the world. To protect against overfishing, commercial and recreational fishing is regulated through the use of licence restrictions, bag or quota limits, restriction on the size range of fish taken and the establishment of no fishing zones.

Competition and conflict

Competition for a finite and potentially declining fish resource has the potential to generate significant conflict between commercial and recreational fishers accessing the same resource. Traditionally recreational anglers point to unsustainable catches by commercial operators as being the key cause of decline in fish stocks. It is worth noting however that recreational catches do exceed commercial takes for a number of target species (Table 15) and that recreational fishing effort will continue to increase with increasing population.

As a measure to reduce conflict, a Recreational Fishing Haven (Figure 39) was established in the lower estuary in 2002, where all netting and trapping is prohibited. There are also other restrictions placed on commercial fishers to reduce potential conflict between the sectors including the ban on weekend netting and netting operations in high visibility areas such as Ballina Quays and the artificial lakes at East Ballina.

Table 15: Commercial and recreational fish catches by species in NSW (1997-2004)

Harvest of key species by fishing sector	Recreational (kg)	Commercial (kg)*
Whiting	394,081	1,181,793
Flathead	886,824	496,335
Bream	728,752	365,383
Garfish	22,672	97,875
Tailor	252,736	190,675
Australian salmon	221,977	790,143
Snapper	116,967	273,159
Trevally	87,530	273,884
Leatherjackets	107,966	117,034
Wrasse/tuskfish/gropers	52,373	69,810
Luderick	280,130	503,600
Mackerels	128,627	443,567
Cod (various)	8,133	35,835
Catfish	94,222	28,965
Mulloway/jewfish	273,703	63,796
Morwong	139,929	429,606
Tuna/bonitos	844,480	1,000,500
Sharks/rays	60,186	441,090
Yellowtail kingfish	180,003	137,349
Prawns (saltwater)	104,833	2,346,976
Blue swimmer crab	154,831	165,461
Squid/cuttlefish	65,717	824,183
Mud crab	30,000	135,144
Lobsters	7,398	120,000
Abalone	10,570	304,000
Nippers	15,167	.
Other Saltwater Species	77,633	12,800,300

Source: DPI Fisheries Survey of Recreational Fishing in NSW
Data derived from a range of Commonwealth and State sources. Other species data based on a 5 year average of ocean fishery landings into NSW

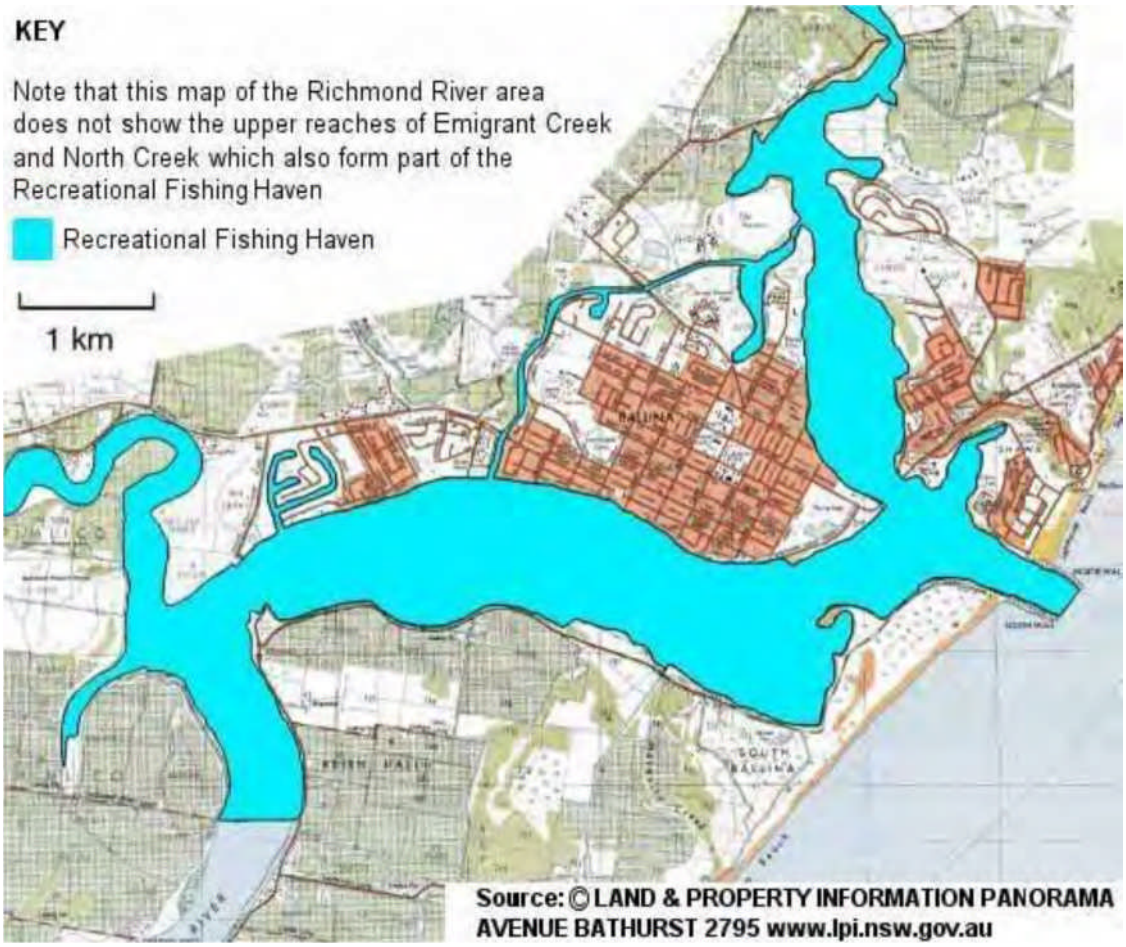


Figure 39: The Recreational Fishing Haven in the Richmond River estuary

The Estuary General Fisheries EIS and associated management strategy (NSW Fisheries, 2003) were produced in response to changes in the way commercial fisheries were managed in NSW. These changes were implemented to provide increased emphasis on environmental sustainability and continued viability of estuarine fisheries. There is concern that the findings and strategies documented in the General Fisheries EIS are not well understood within the community and that commercial fishers are being unfairly blamed for fish decline in the estuary.

Despite this, there is increasing recognition in both the recreational and commercial fishing sectors that their respective activities are highly regulated and that factors such as the major fish kills in 2001 and 2008, as well as the cumulative effects of habitat degradation, fish migration barriers and declining water quality are all contributing to reduced fish stocks. The 2008 fish kill and ensuing temporary fishing closure polarised community views on who was to blame and what was to be done to avoid repeat occurrences.

It is also important to acknowledge traditional Aboriginal fishing rights and practices in accordance with Native Title.

Oyster aquaculture

The EPS (WBM, 2006) notes that Ballina was named after the local Aboriginal name of ‘bullenah’ which means ‘place where oysters are plentiful’. Culture of the native Sydney Rock Oyster is the only aquaculture industry in the Richmond River estuary and is concentrated in the lower reaches of North Creek and Richmond River.

There are a range of issues affecting the oyster aquaculture industry in the Richmond River estuary:

- QX disease is a major threat to both production and saleability of oysters from the estuary and is caused by protozoan infestation of the oyster gut. After infection, the oyster's digestive gland is destroyed and the oyster cannot take up nutrients. At this stage, oysters rapidly loose condition and there is a high mortality rate. Although the triggers for QX disease are not fully understood, it is suspected that poor water quality is a major stressor which reduces an oyster's resistance to the disease. DPI is continuing research into management of the disease, including the development of QX resistant strains of the Sydney Rock Oyster. The Richmond River is classified as a high risk QX waterway which restricts the export of oysters to other, lower risk, estuaries. QX resistant strains are being grown in the Richmond estuary however oyster mortality is still occurring.

Plate 26: Oysters collected from the Richmond River with QX disease

Source: WBM, 2006

- Oysters are well known for their ability to accumulate contaminants from the surrounding water and therefore the industry relies on good ambient water quality to both maintain the health of the oysters and to ensure that the product is fit for human consumption. The saleability of oysters is not only governed by the NSW Food Authority which imposes monitoring requirements and imposes harvest restrictions when required but also the public perception of the environment they are grown in. The presence of periodically high levels of faecal coliforms in North Creek has resulted in harvest closures which was reported in the EPS (WBM, 2006) as typically extending for 9 months of the year. The presence of pesticide residues and potential effect on the oyster industry is an ongoing concern;
- Vandalism of oyster culture racks and theft of oysters is an emerging issue facing the industry. Apart from the commercial losses suffered by the growers, and risks to the viability of the industry there are significant human health risks. Oysters stolen and sold on the black market are not covered by the NSW Shellfish Program, may come from areas subject to closures are not depurated and are not subject to quality control testing.

No.	Fisheries Management and Aquaculture Issues
I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks
I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled
I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods

7.14.2 Management Objectives

Table 16 shows the relationship between Fisheries and Aquaculture issues, related values and management objectives.

Table 16: Relationship between Fisheries and Aquaculture Values, Issues and Objectives

Values	Issues	Objectives
• Commercial fishing and oyster aquaculture contribute to the local and regional economy • The estuary and particularly the lower estuary is considered to be a key attraction for tourists and recreational users to the area, with associated economic benefits • The Richmond River Estuary has high cultural and spiritual significance to local Aboriginal communities • The estuary and foreshore areas are highly valued by the community and visitors for recreational activities	I24 - Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks I25 - QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled I26 - Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods	O4 - To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement O5 - To reduce pollutant loads to the estuary O7 - To minimise the frequency and severity of environmental events such as fish kills O8 - To optimise flood mitigation works and flow control structures to improve estuarine water quality O11 - To provide for increased use of the estuary whilst minimising environmental impact and conflict between users O14 - To enhance sustainable commercial return from industries relying on the estuary and the floodplain

7.14.3 Potential Management Options

None of the issues relating to fisheries and aquaculture management are unique to the Richmond River estuary and are currently being addressed to various degrees by industry regulation licensing and research programs. Work currently being undertaken on an industry or state-wide basis includes:

- Setting of bag and size limits for recreational anglers. This information is provided at a number of boat ramps within the Richmond River estuary, as well as at bait and tackle stores and with information provided when obtaining recreational fishing licences in NSW;
- Commercial fishing is licensed in NSW and catches are monitored through co-op returns. There is on-going review of catch and effort data for all estuaries in NSW including the Richmond;
- The impact of changes in fisheries regulation for NSW estuaries was assessed under the General Fisheries EIS produced in 2003. The associated strategy provides measures to address a range of goals including conservation of biological diversity, sustainable harvesting, conservation of threatened species and ecological communities, resourcing sharing and conflict minimisation, on-going commercial viability, management efficiency, knowledge improvement as well as monitoring and review. Many of these measures are consistent with the aims of the CZMP process and are supported; and
- Research into QX disease triggers and development of QX disease resistant strains of the Sydney Rock Oyster is being undertaken by Industry & Investment NSW.

On a local scale there are strong linkages to other management options identified to manage broad scale issues within the estuary as follows:

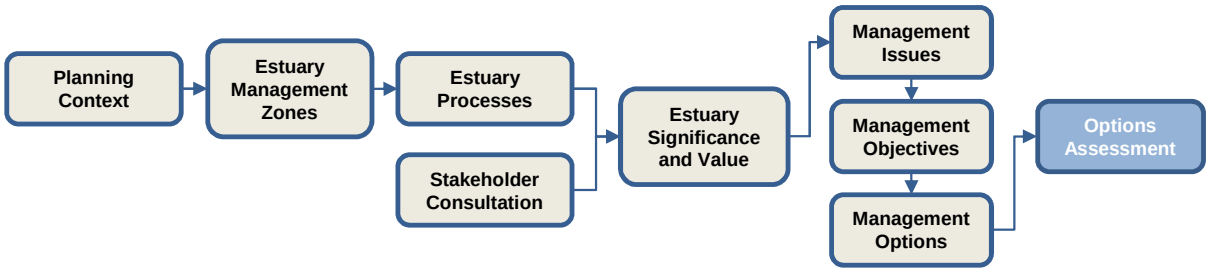
- Water quality in the estuary is a key determinant in achieving the objectives for fisheries and aquaculture management in the Richmond River estuary. Any measures that result in improvements in water quality in the estuary will be beneficial, so the options identified for floodplain management, farm management, riparian zone management, waterway usage, wastewater and urban runoff are particularly relevant; and
- Continued public education is important to increase awareness of commercial and recreational fishing impacts, to improve community understanding of indigenous fishing rights, to contribute to reducing pollutant load to the estuary (both rural and urban runoff) as well as reducing direct impacts such as boating damage to critical habitats and over-fishing.

Specific options identified to address local fisheries and aquaculture issues and to enhance the effectiveness of broader strategies are:

- Identify faecal contamination sources in North Creek and evaluate the most appropriate control measures; and
- Provide information links so that key research findings in the fisheries and aquaculture sector are communicated to the public (e.g. via council newsletters, web sites, etc).

No.	Fisheries and Aquaculture Management Options
29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public
30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures

8. ESTUARY MANAGEMENT OPTIONS ASSESSMENT



A suite of options available for the sustainable management of the estuary have been compiled in Section 7 and developed to a point where the options can be compared and prioritised. Further detail is provided in Appendix 4.

8.1 Assessment and Prioritisation of Options

The evaluation of potential management options is critical to the development of management strategies. This has been undertaken as follows:

- All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan;
- The individual options were assessed to determine the effectiveness in addressing the priority issues ("Issues Score");
- The individual management options were assigned an "Option Benefit Score"; and
- The Average Option Benefit Scores (average of the Option Benefit Scores) for each category of option were visually compared with the associated issue priority.

Appendix 4 provides a detailed description of the options assessment process. The results of the options assessment (Option Benefit Score vs Issues Score) are shown in Figure 40.

The options considered in this study have been identified for a range of purposes e.g. studies that are required to further refine or prioritise management actions, options that are complementary i.e. they achieve a similar outcome but are applicable to different geographical areas and/or issues, and options that are mutually exclusive in that only one of the options is appropriate. Because of this, the assessment of individual options does not provide a full representation of the required management effort. To address this, the options have been assessed as bundles applicable to each issue category.

Figure 41 compares the Average Option Benefit Score and the Total Issues Scores for each category of issues (Strategies) from Section 7. The Strategies have been assigned a low, medium or high priority based on their capacity to address the identified issues and their overall benefit. Administration and Governance, Climate Change and Monitoring and Evaluation are considered to be fundamental management strategies for the CZMP. These strategies have not been prioritised in the same way as the other strategies and are not included in this plot.

The classification of strategies as low priority for management is not a reflection of the level of importance of these factors, but rather an indication of the capacity of the actions contained in these strategies to achieve the defined objectives in terms of overall estuary health.

Based on the priorities displayed here, the management strategies will be developed as part of the Draft CZMP. The strategies (in priority order) and their component options are shown in Table 17.

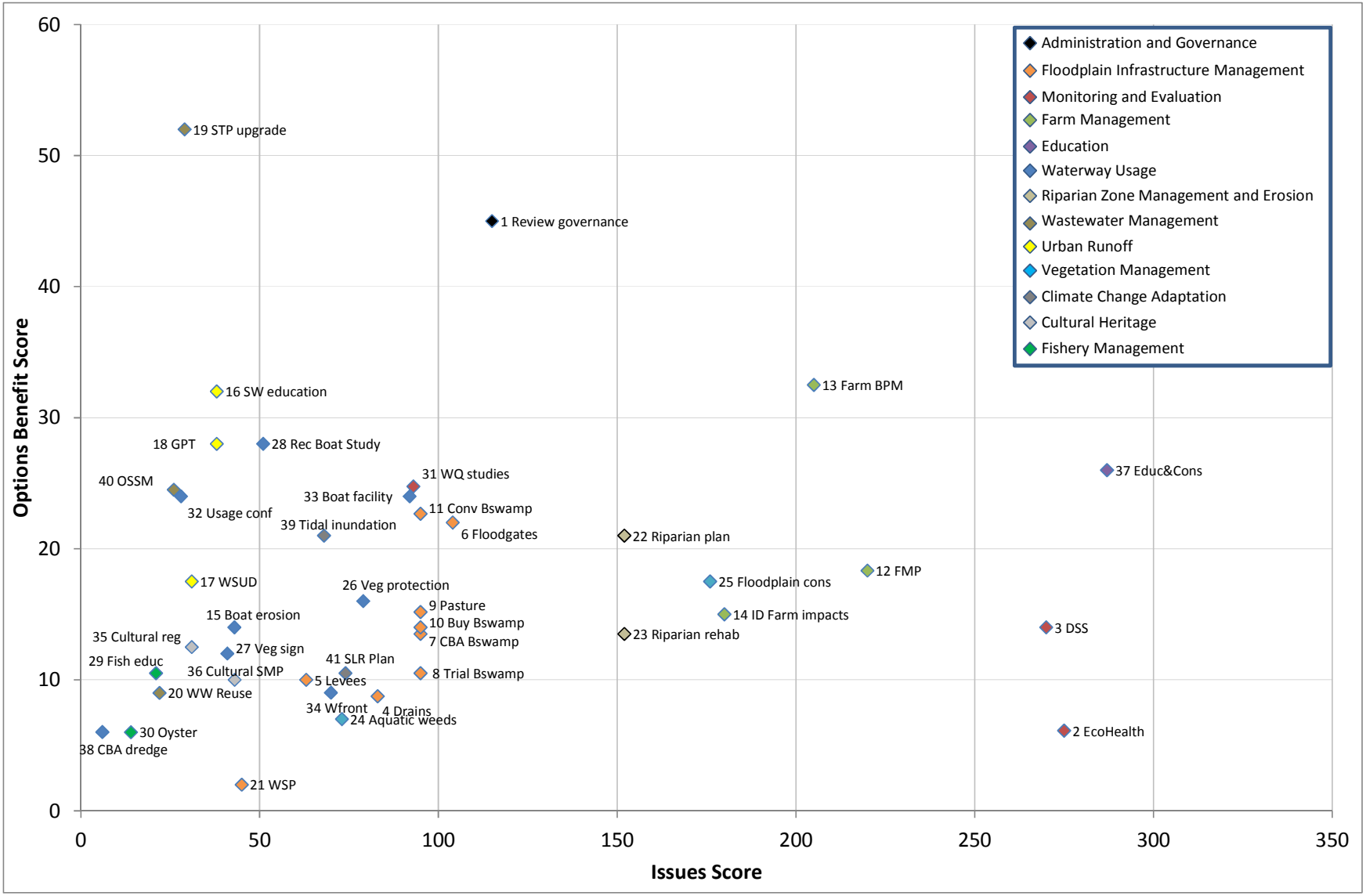
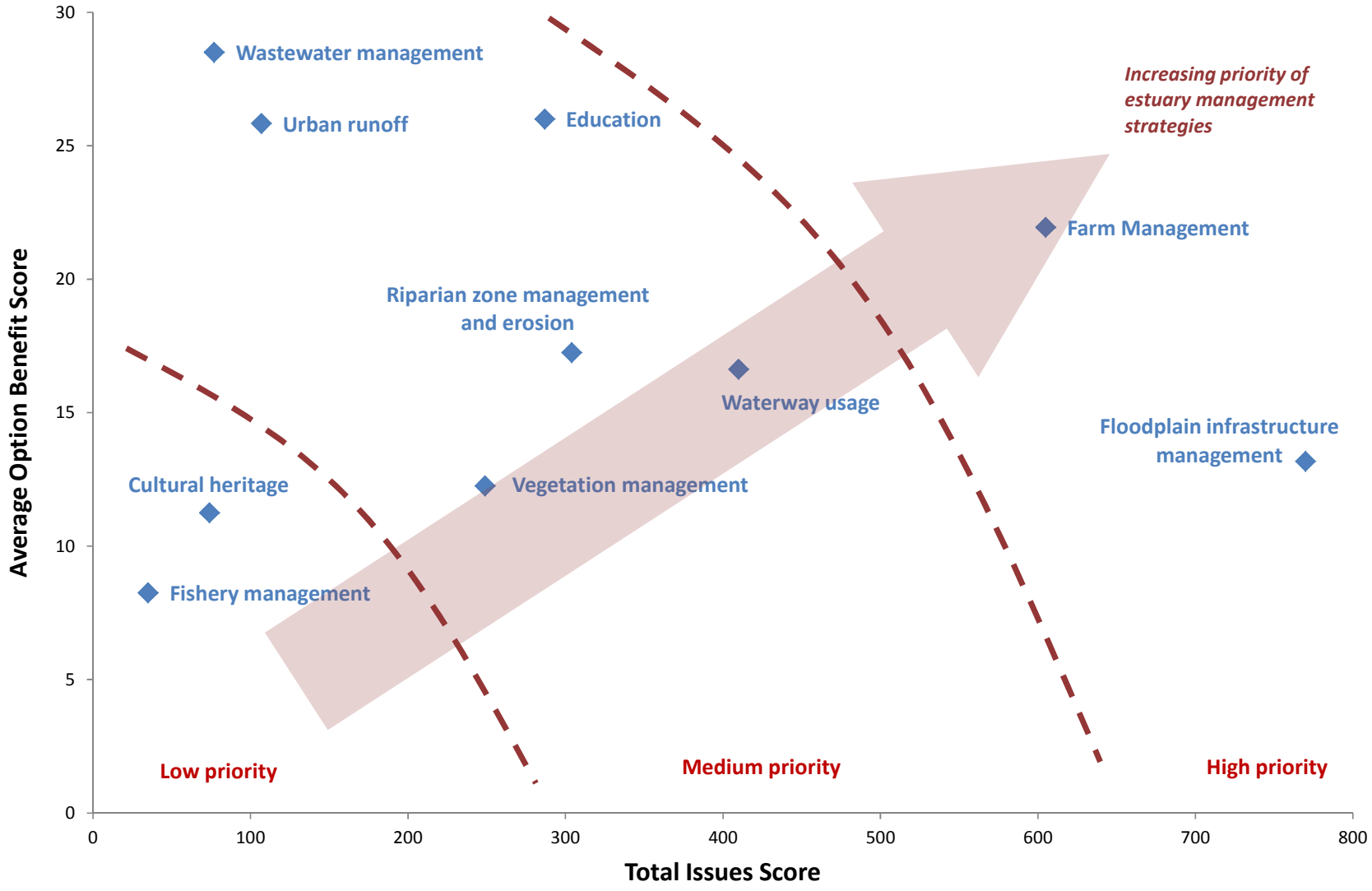


Figure 40 - Assessment of Management Options



*Note that strategies considered to be fundamental management considerations were not prioritised i.e. Administration and Gov ernance and Climate Change Adaptation

Figure 41: Relative Priority of Management Strategies

Table 17: Prioritised Management Strategies and Options

FUNDAMENTAL MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Administration and Governance	
1	Review estuary governance and administration
Climate Change Adaptation	
39	Assessment and mapping of tidal inundation extent including potential sea level rise
41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management
Monitoring and Evaluation	
2	EcoHealth monitoring program
3	Develop catchment/water quality modelling tool to support decision making

HIGH PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Floodplain Infrastructure Management	
4	Identify, prioritise and infill/reshape redundant drains
5	Identify, prioritise and redesign/remodel levees
6	Review floodgate management protocols
7	Cost benefit analysis of backswamp farming activities
8	Scientific trials to investigate strategies for retention of water on backswamp areas
9	Changes in pasture and harvest management including changes to inundation tolerant species
10	Retirement/buy back backswamp areas and return to wetlands
11	Work with backswamp property owners to identify alternative management strategies
21	Review water sharing plans regarding groundwater extraction and ASS effects
Farm Management	
12	Farm management planning for priority properties
13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines
14	Identify high impact farming activities and investigate alternatives

MEDIUM PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Riparian Zone Management and Erosion	
22	Riparian buffer zone establishment (planning)
23	Identify priority riparian areas and rehabilitate
Vegetation Management	
24	Aquatic weed management
25	Retain, rehabilitate and conserve existing native floodplain vegetation
Education	
37	Estuary-wide community education and consultation program
Waterway Usage	
15	Review boat passage areas impacted by erosion
26	Zoning to prevent access to sensitive estuarine vegetation areas
27	Estuarine vegetation signage / education to protect sensitive areas
28	Implement Recreational Boating Study actions
32	Investigate usage conflicts and need for management
33	Develop strategic plan for estuary usage
34	Review of waterfront structures and licensing
38	Cost benefit analysis of dredging operations in lower estuary
Wastewater Management	
19	Upgrade / augment STPs where required
20	Wastewater Reuse
40	Ongoing on-site sewerage management inspections and improvements
Urban Runoff	
16	Stormwater education
17	WSUD for new developments
18	Retrofit GPTs and other stormwater improvement devices

LOW PRIORITY MANAGEMENT STRATEGIES AND MANAGEMENT OPTIONS	
Cultural Heritage	
35	Identification and recording of cultural sites available to council planners
36	Cultural Site management plans
Fishery Management	
29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public
30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures
31	Further research into sources of water quality issues in North Creek

9. PREPARATION OF THE COASTAL ZONE MANAGEMENT PLAN

9.1 Development of the Coastal Zone Management Plan

Based on the options identified as part of this Draft EMS, a workable and prioritised schedule for implementing the management strategies will be developed and presented in the Draft CZMP for the Richmond River Estuary (Volume 1).

The preparation of the Draft CZMP will include development of:

- Management strategies based on the options identified in this Draft EMS;
- Broad actions (managerial, operational, planning, design and construction) required to implement each option;
- A 10 year schedule of actions required to implement the management strategy; and
- Key performance indicators (KPIs) and targets for the successful implementation of the actions.

Management actions will be assessed as immediate, ongoing, short term (1 - 3 years), medium term (4 - 6 years) and long term (7+ years). The implementation of some options may be reliant on pre-requisite actions that cannot be completed within the 10 year timeframe of this plan, but will be commenced within the implementation timeframe.

Management strategies will identify those responsible for the delivery of each action, the estimated costs to be faced and potential sources of funding. The strategies will consider and support the broader policies, strategies and targets identified at the state, regional and catchment level. Where issues are already being addressed by other management strategies, this will be recognised in the Draft CZMP.

A monitoring program will be developed for the Draft CZMP, utilising the KPIs, for the purposes of the on-going review and adaptation of the Draft CZMP to ensure it continues to deliver sustainable outcomes. For the identified KPIs, and the actions required to deliver them, requirements will be brought together to create a comprehensive, outcomes-focussed monitoring regime. Where relevant, links to the Councils' existing environmental monitoring and reporting (such as the State of the Environment reports) activities will be developed.

The implementation of the plan will be supported by a process for reviewing the effectiveness of the plan and adapting it as required. This aspect of the project is essential for ensuring that the estuary management options identified become a reality and that the estuary is better managed into the future.

GLOSSARY AND ABBREVIATIONS

Acid sulfate soils (ASS)	Holocene soils occurring in low lying floodplain areas with high concentrations of iron pyrite, formed as the by-product of sulfate reduction. ASS formed approximately 7,000-3,000 years before present when post-glacial sea levels reached their current level creating vast intertidal mangrove swamps.
Algal bloom	The rapid growth of phytoplankton resulting in a high biomass in the water column.
Anoxic	An oxygen-free environment.
Antecedent	Preceding the present.
Anthropogenic	Any phenomenon caused by human activities.
BASIX	Building Sustainability Index
Benthic microalgae (BMA)	Microscopic algae living in the surface sediments
Benthic	Belonging to the bottom, or sediments, of the estuary.
Bio-available	Nutrient forms (usually inorganic) available for plant growth.
Biological oxygen demand (BOD)	A measure of the amount of oxygen that will be consumed by biological processes over a given time period (usually 5 days).
Biomass	The living weight of plant or animal material (organic matter).
Blackwater	A collective term used to describe low oxygen floodwaters emanating from backswamp areas and floodplains.
BSC	Ballina Shire Council
CAP	Catchment Action Plan
Chemical oxygen demand (COD)	A measure of the amount of oxygen that will be consumed by chemical processes over a given time period (usually 5 days).
Chlorophyll-a	The green pigment in plants used to capture and use energy from sunlight to form organic matter (see photosynthesis). Concentrations of chlorophyll-a are used as an indicator for phytoplankton and benthic algae biomass.
CZMP	Coastal Zone Management Plan (equivalent to EMP).
DECCW	former NSW Department of Environment, Climate Change and Water
Diffuse Source Pollution	Non-point source pollution such as sediment or nutrients from catchment runoff or groundwater inputs.
DPI	Department of Primary Industries
Ecosystem	Refers to all the biological and physical parts of a biological unit (e.g. an estuary, forest, or planet) and their interconnections.
EMC	Estuary Management Committee
EMS	Estuary Management Study
EPA	Environment Protection Authority
Eutrophication	The process of nutrient enrichment of a water body resulting in the increase in plant biomass (algal blooms) and bacterial decay (heterotrophic activity). Often results in a reduction in species diversity, visual amenity, and the prevalence of toxic algal species.
Foodchain	The predator / prey interactions of an ecosystem component.
Foodweb	Foodchain interactions of the whole ecosystem.
Freshwater flushing time	The time (in days) that freshwater stays within an estuary before being transported to the sea by advection and tidal mixing.
Grazing	The eating of plants (e.g. phytoplankton) by animals (e.g. zooplankton).
Hypoxic	Critically low concentrations of dissolved oxygen (see anoxic).
LCC	Lismore City Council

LEP	Local Environmental Plan
Light attenuation	The absorbance of sunlight by dissolved and particulate matter in a water body.
LPMA	Land and Property Management Authority (formerly Department of Lands)
Monosulfidic Black Ooze (MBO)	An iron sulfide compound formed as a by-product of sulfate reduction. MBOs commonly form in acid environments with high organic matter supply and have a high chemical oxygen demand.
NOW	NSW Office of Water
NPWS	National Parks and Wildlife Service
NRCMA	Northern Rivers Catchment Management Authority
NRM	Natural Resource Management
Nutrient budget	A simple model quantifying nutrient loadings (by weight) to a waterway from different sources over a given time period (e.g. one year).
Nutrient limitation	The restriction of phytoplankton growth by the low concentration (availability) of a nutrient.
OEH	Office of Environment and Heritage
Physico-chemical	Basic water quality parameters e.g. temperature, pH, conductivity, turbidity.
Phytoplankton	Microscopic single-cell plants growing in the water column.
Point Source Pollution	A single point of pollutant discharge. For example, effluent from a sewage treatment plant.
Primary production	The formation of organic matter by autotrophs (e.g. phytoplankton).
Pristine	Undisturbed by human activities such as urban and agricultural development, pollution, erosion, weed infestations etc.
Reticulated Sewage System	Sewage piped to a centralised sewage treatment plant for treatment and disposal.
RRCC	Richmond River County Council
RVC	Richmond Valley Council
SEPP	State Environmental Planning Policy
Sulfate reduction	The bacterial breakdown of organic matter in anoxic sediments using sulfate instead of oxygen. Produces hydrogen sulfide, the ‘rotten egg gas’ smell common in muddy sediments.
STP	Sewage Treatment Plant. Raw sewage is collected from homes and businesses and transported via a network of pipes and pump stations to the sewage treatment plant, a centralised system for treatment and disposal.
Turbidity	A measure of the amount of light-attenuating particles in a water body.
Well-mixed	Where there is a little difference in salinity (or dissolved oxygen) between the surface and bottom water in the water column of an estuary.

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Appendix 1: Planning Context

This Appendix provides detailed information on the planning processes that apply to the management of the Richmond River estuary.

1. PLANNING CONTEXT

1.1 NSW Coastal Zone Management Planning Process

1.1.1 NSW State Rivers and Estuaries Policy, 1993

The policy requires that the sustainability of the river and estuarine resources and their biophysical functions will be given explicit consideration in resource management decision making. The objectives of the policy are to manage the rivers and estuaries of NSW in ways which:

- Slow, halt or reverse the overall rate of degradation in their systems;
- Ensure the long-term sustainability of their essential biophysical functions, and
- Maintain the beneficial use of these resources.

These objectives will be achieved through the application of the following management principles:

- Those uses of rivers and estuaries which are non-degrading should be encouraged;
- Non-sustainable resource uses which are not essential should be progressively phased out;
- Environmentally degrading processes and practices should be replaced with more efficient and less degrading alternatives;
- Environmental degraded areas should be rehabilitated and their biophysical functions restored;
- Remnant areas of significant environmental values should be accorded special protection; and
- An ethos for the sustainable management or river and estuarine resources should be encouraged in all agencies and individuals who own, manage or use these resources, and its practical application enabled.

1.1.2 Coastal Zone Management Program

The NSW Government's Estuary Management Program was established in 1992 with the aim of protecting and restoring the health and functionality of estuaries along the NSW coastline and to implement the State Government's Estuary Management Policy, 1992. The program encourages local stakeholders to responsibly manage their local estuaries through the formation of an Estuary Management Committee and the development of an Estuary Management Plan that reflects the needs of the local community and the environment, identifying issues, possible solutions and methods to implement them.

Coastal councils are now required to prepare a coastal zone management plan (CZMP) in accordance with the guidelines adopted in 2010 under section 55D of the Coastal Protection Act, 1979 (DECCW 2010c). The Guidelines replace the draft Estuary Management Manual (NSW Government, 1992).

The CZMP supports the goals and objectives of the NSW Coastal Policy 1997 and the NSW Sea Level Rise Policy Statement, 2009 and assists in implementing integrated coastal zone management. The draft CZMP was prepared in accordance with Part 4A of the Coastal Protection Act, 1979 and CZMP guidelines (DECCW, 2010c).

Councils are to submit draft CZMPs to the Minister administering the Coastal Protection Act 1979 for certification under the Act. When a draft CZMP is submitted, the Minister will make an assessment of whether to certify the CZMP by considering whether it meets the requirements of the Coastal Protection

Act 1979 and the minimum requirements in these guidelines. The Minister may refer the draft CZMP to the NSW Coastal Panel for review (Figure 1).

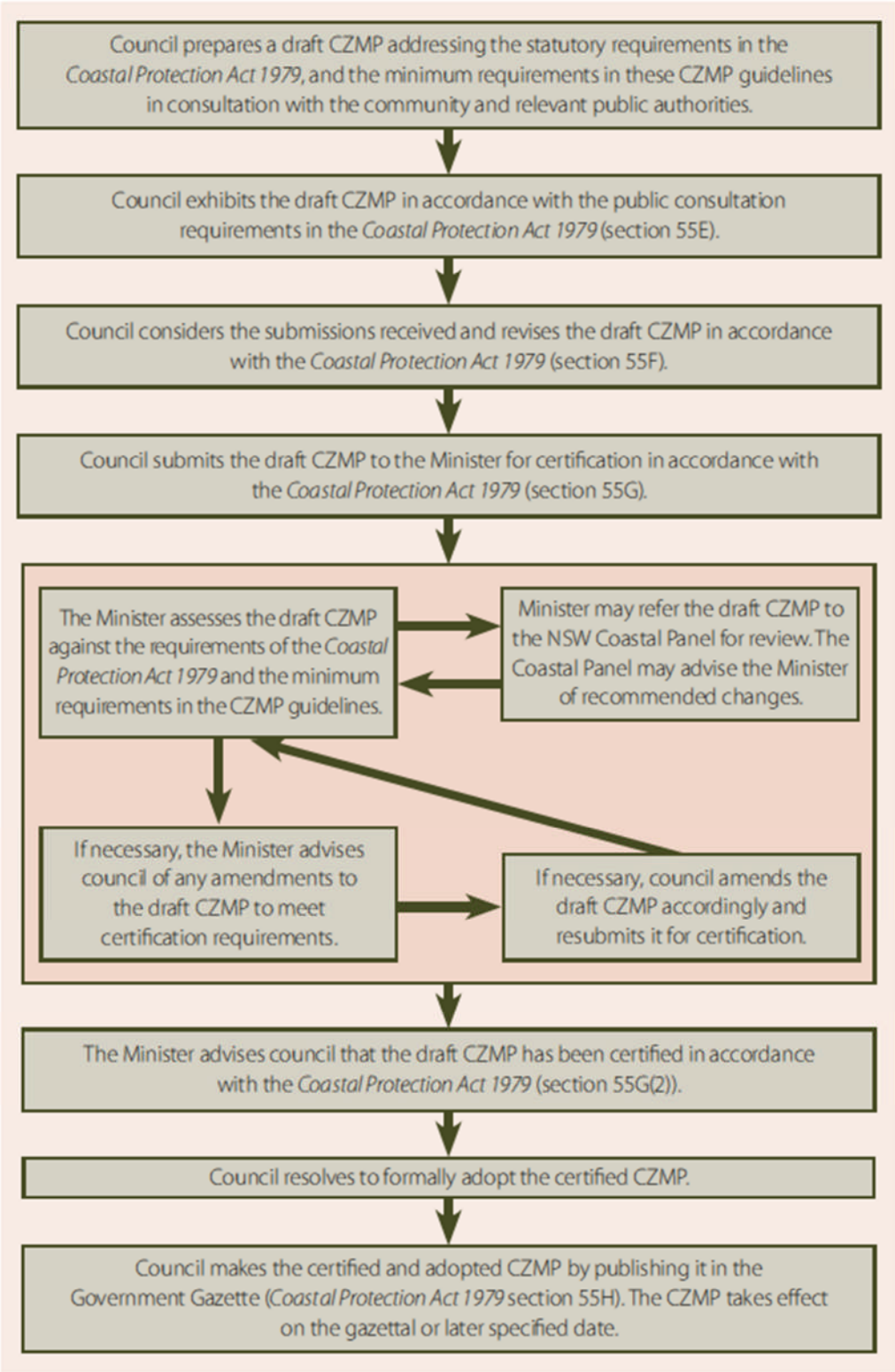

Figure 1: CZMP preparation and certification process (DECCW, 2010c)

1.1.3 NSW Coastal Policy, 1997

The NSW Coastal Policy was introduced with the aim of protecting and conserving coastal environments, including estuarine environments, for future generations. The Policy responds to the fundamental challenge to provide for population growth and economic development without placing the natural, cultural, spiritual and heritage values of the coastal environment at risk. To achieve this, the Policy has a strong integrating philosophy based on the principles of ecologically sustainable development (ESD).

The Coastal Policy represents an attempt by Government to better co-ordinate the management of the coast by identifying, in a single document, the State's various management policies, programs and standards as they apply to a defined coastal zone. These policies, programs and standards frequently obtain their legitimacy from other legislation or programs and are often implemented by local councils or the community, either in partnership with the State Government or independently.

The Policy addresses a number of key coastal themes including:

- Population growth in terms of physical locations and absolute limits;
- Coastal water quality issues, especially in estuaries;
- Disturbance of acid sulfate soils;
- Establishing an adequate, comprehensive and representative system of reserves;
- Better integration of the range of government agencies and community organisations involved in coastal planning and management;
- Indigenous and European cultural heritage; and
- Integration of the principles of ESD into coastal zone management and decision making.

The management of the coastal zone is the responsibility of a range of government agencies, local councils and the community. The Policy provides a framework for the balanced and coordinated management of the coast's unique physical, ecological, cultural and economic attributes.

1.2 Other Relevant Management Policies

1.2.1 NSW Wetland Policy, 2010

Consistent with the priority on natural resources management in the NSW State Plan to deliver better outcomes for native vegetation, biodiversity, land, rivers and coastal waterways, this policy aims to provide for the protection, ecologically sustainable use and management of NSW wetlands.

The policy covers all wetlands in the state, including those that are mapped and the many that are yet to be formally identified in recognition of their critical importance in the ecological and hydrological systems of the state's catchments.

The State Plan, which this policy is aligned with, includes a target for improving the condition of 'important wetlands' (defined as being those listed under the Ramsar Convention or in the Directory of Important Wetlands in Australia, Environment Australia, 2001). Within the Richmond River estuary, the Bundjalung National Park and the Broadwater wetlands are listed as nationally important wetlands.

Other significant wetlands in NSW include those mapped under State environmental planning policy no. 14 – Coastal wetlands (SEPP 14) and others listed as endangered ecological communities under the Threatened Species Conservation Act 1995. Numerous other wetlands also provide significant ecosystem services and are valued by local communities. In recognition of the State Plan wetland target, and to

maintain an extensive and diverse state-wide network of wetlands, this policy proposes to focus on sites of:

- International importance (RAMSAR sites);
- National importance, that is, sites listed in the Directory of important wetlands of Australia;
- Regional significance, for example, sites identified by regional organisations dealing with natural resource management in consultation with their communities.

Opportunities to support local wetlands in partnership with land holders should also be considered and identified in investment or management plans.

1.2.2 NSW State Groundwater Policy Framework Document, 1997

The purpose of the Groundwater Framework Policy document is to provide a clear NSW government policy direction on the ecologically sustainable management of the State's groundwater resources for the people of NSW. The focus of the Policy is on water below the ground surface in a geological structure or formation, and on the ecosystems from which these waters are recharged or into which they discharge. It provides for the better consideration of all issues which affect, or are likely to affect the condition and functioning of the resources of these areas including water chemistry, geology, aquifer recharge and discharge, and dependent ecosystems such as wetlands, lakes and streams, springs and seeps. It requires that careful consideration be given to all factors affecting the stability, vulnerability, and productivity of these systems.

1.2.3 NSW Government Sea Level Rise Policy Statement, 2009

To support sea level rise adaptation, the NSW Government has prepared a Sea Level Rise Policy Statement. This sets out the Government's approach to sea level rise, the risks to property owners from coastal processes and assistance that Government provides to Councils to reduce the risks of coastal hazards.

The Policy Statement includes sea level planning benchmarks which have been developed to support consistent consideration of sea level rise in land-use planning and coastal investment decision-making. The adopted benchmarks are for a rise relative to 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. These benchmarks represent the Government's guidance on sea level rise projections for use in decision-making.

1.2.4 NSW Oyster Industry Sustainable Aquaculture Strategy, 2006

The NSW Oyster Industry Sustainable Aquaculture Strategy (OISAS):

- identifies those areas within NSW estuaries where oyster aquaculture is a suitable and priority outcome;
- secures resource access rights for present and future oyster farmers throughout NSW;
- documents and promotes environmental, social and economic best practice for NSW oyster farming and ensures that the principles of ecological sustainable development, community expectations and the needs of other user groups are integrated into the management and operation of the NSW oyster industry;
- formalises industry's commitment to environmental sustainable practices and a duty of care for the environment in which the industry is located;

- provides a framework for the operation and development of a viable and sustainable NSW oyster aquaculture industry with a clear approval regime and up-front certainty for existing industry participants, new industry entrants, the community and decision makers;
- identifies the key water quality parameters necessary for sustainable oyster aquaculture and establishes a mechanism to maintain and where possible improve the environmental conditions required for sustainable oyster production; and
- ensures that the water quality requirements for oyster growing are considered in the State's land and water management and strategic planning framework.

1.2.5 NSW Diffuse Source Water Pollution Strategy

The NSW Diffuse Source Water Pollution Strategy provides a framework for coordinating efforts in reducing diffuse source water pollution across NSW. The Strategy promotes partnerships, provides a guide for investment, and provides a means to share information on projects and their outcomes across the State. Developing and implementing this Strategy is a joint initiative by the State's natural resource managers (at State, regional and local government levels), building on and supporting a range of existing diffuse source water pollution management actions.

The main aim of the Strategy is to reduce diffuse source water pollution inputs into all NSW surface and ground water and contribute towards the community agreed NSW water quality objectives and State-wide Natural Resource Management targets listed in the State Plan - A new direction for NSW.

A Priority Action Plan has been developed as part of the NSW Diffuse Source Water Pollution Strategy. It identifies agreed projects that will be progressed across NSW to help improve management of priority diffuse source water pollution problems. The first NSW Diffuse Source Water Pollution Strategy Annual Report was published in November 2010. It reports on the implementation of the individual actions identified it the Priority Action Plan.

1.3 Regional Management Plans

1.3.1 Estuary General Fisheries Management Strategy

The Estuary General Fishery is one of nine major commercial fisheries in NSW. It is a large and diverse fishery harvesting a wide range of finfish and shellfish for sale from estuarine waters using a range of commercial fishing gear. The fishery also includes the taking of invertebrates (such as beachworms and pipis) by hand from ocean beaches. The strategy contains the goals and objectives for the fishery, a detailed description of the way the fishery operates, and describes the management framework for the future. It also outlines a program for monitoring the biological, social and economic performance of the fishery, establishes trigger points for the review of the strategy, and requires annual reporting on performance in order to ensure the objectives set out in the strategy are met. Information about the impacts of harvesting by other fishing sectors (such as recreational fishing) is also provided, however the rules applying to such sectors are dealt with under separate management arrangements and are not the subject of this strategy.

1.3.2 Status of Fisheries Resources Report

The Status of Fisheries Resources in NSW 2006/07 is a general overview of the state of fish populations that are harvested by commercial fisheries that are licensed by NSW DPI. In particular, the document contains a summary of the state of knowledge of all 92 key species taken by the Estuary General, Estuary Prawn Trawl, Ocean Hauling, Ocean Trawl and Ocean Trap and Line Fisheries.

1.3.3 Northern Rivers Regional Biodiversity Management Plan

The Northern Rivers Regional Biodiversity Management Plan constitutes the national regional recovery plan under the Environment Protection and Biodiversity Conservation Act 1999 for threatened species and ecological communities principally distributed in the Northern Rivers Region of NSW. The Plan is part of an Australian Government-funded pilot to trial the integration of regional recovery and threat abatement planning. It provides a regional approach to the delivery of recovery actions necessary to ensure the long-term viability of threatened species and ecological communities in the Region.

1.4 Local Management Plans

1.4.1 Catchment Action Plan

Catchment management has a direct impact on estuarine environments. The condition of an estuary reflects the land-use activities occurring in the catchment upstream and it is critical to consider the catchment management framework in relation to estuary management planning.

The Catchment Management Authorities Act 2003 requires each catchment management authority to prepare catchment action plans in partnership with regional community and government agencies. A catchment action plan sets out the long-term direction for community and government investment and action in natural resource management. It is the primary mechanism for regional delivery of the NSW State Plan's targets for biodiversity, water, land and community.

The 2006 Northern Rivers Catchment Action Plan (CAP) has been developed by the Northern Rivers Catchment Management Authority (NRCMA) under the Catchment Management Authorities Act 2003 (NRCMA, 2006). The Plan sets a 10-year investment strategy for targeted investment for the region which extends over most of the NSW North Coast, from the Camden Haven River in the south to the Queensland border in the north and extending west to the Northern Tablelands.

The CAP draws together targets outlined in three previous Catchment Blueprints that have been reviewed and evaluated through a facilitated process of stakeholder engagement. Targets aim to improve the natural assets such as water, coastal landscapes and estuaries, the marine environment, soil, cultural heritage and biodiversity. The CAP also promotes the value of communities in the catchment, and aims to capture the communities' priorities and aspirations for the protection and enhancement of natural resources in the region.

The CAP outlines many varied approaches to achieve targets, the majority of which rely on voluntary input from landholders and other stakeholders. The CAP also provides priorities to guide a range of other processes including local government and NSW Government regulatory processes.

The Natural Resources Commission (NRC) has a statutory role to audit whether the NSW CAPs are being implemented effectively. The audit of the Northern Rivers CAP was undertaken in November 2009.

1.4.2 Interim Water Quality and River Flow Objectives

The ANZECC Guidelines for Fresh and Marine Water Quality (2000) provide a framework for conserving ambient water quality in rivers, lakes, estuaries and marine waters. This framework is used to develop water quality and river flow objectives.

DECCW (then EPA) has developed water quality and river flow objectives for the Richmond River Catchment. Each objective aims to improve river health by recognising the importance of natural river flow patterns. Councils are required to consider these environmental values and long-term goals when assessing and managing the likely impact of its activities on waterways.

The objectives were developed in a whole of government process lead by DECCW. Objectives were developed through extensive community consultation and are intended to assist resource managers in assessing and setting targets for environmental values with associated water quality indicators defined by ANZECC.

There are eleven WQOs that provide reference levels to guide water quality planning and management. The objectives consist of three parts, environmental values, their indicators, and their numerical criteria. Environmental values outline values and beneficial uses of the environment that are important to a community. The primary contact recreation environmental value for example, includes swimming or any activity with a likelihood of water being swallowed. The indicators provide a measurement of specific environmental trends while the criteria provide the framework for measuring how close current water quality is to meeting the desired levels.

1.4.3 Water Sharing Plan

DECCW has prepared a draft Water Sharing Plan for the Richmond River Area unregulated, regulated and alluvial water sources (under the management and licensing provisions of the Water Management Act 2000). The draft Plan was placed on public exhibition between 9 November 2009 and 15 January 2010. The Plan focuses on water sharing rules for the environment, access rules and extraction allowances and dealing rules which control the trade of water.

1.4.4 National Parks and Reserves Plans of Management

The management of national parks, nature reserves and state conservation areas in NSW is in the context of the legislative and policy framework, primarily the National Parks and Wildlife Act 1974 (NPW Act), the NPW Regulation, Threatened Species Conservation Act 1995 (TSC Act) and the policies of the National Parks and Wildlife Service (NPWS).

Other legislation, international agreements and charters may also apply to management of the area. In particular, the Environmental Planning and Assessment Act 1979 (EPA Act) may require the assessment and mitigation of the environmental impacts of works proposed in this plan. The Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) also applies in relation to actions that may impact on matters of national environmental significance, such as migratory species and threatened species listed under that Act.

A plan of management is a statutory document under the NPW Act. Once the Minister has adopted a plan, no operations may be undertaken within the planning area except in accordance with this plan. This plan will also apply to any future additions to the planning area. Should management strategies or works be proposed for the planning area or any additions that are not consistent with this plan, an amendment to this plan or a new plan will be prepared and exhibited for public comment.

The following Plans of Management are relevant to the Richmond River estuary:

- Bungawalbin and Yarringully Parks and Reserves Draft Plan of Management;
- Richmond River Nature Reserve Plan of Management (2005); and
- Broadwater National Park, Bundjalung National Park and Iluka Nature Reserve Plan of Management (2005).
- Ballina Nature Reserve Plan of Management (2003)

1.4.5 Crown Reserves Plans of Management

Plans of Management for Crown Reserves have been prepared in accordance with the provisions of Section 112 of the Crown Lands Act 1989. The plans aim to enhance public access, tourism and recreation opportunities on the Crown Reserves. Issues addressed include:

- Improved facilities and infrastructure for open space and foreshore areas
- Improved public foreshore access and pedestrian linkages
- Management of native vegetation
- Management of foreshore erosion
- A range of strategies to support the long-term financial sustainability of the foreshore reserve system

Relevant plans include:

- Woodburn Master Plan, Plan of Management and Risk Management Plan (draft 2010);
- Coraki Master Plan, Plan of Management and Risk Management Plan (draft 2010); and
- Evans Head Coastal Reserves Plan of Management (2010).

1.4.6 Wilsons River Catchment Plan

The Wilsons River Catchment Management Plan (CMP) is a risk-based catchment and investment strategy to direct activities aimed at protecting drinking water quality at the Wilsons River Source and an environmental monitoring program to underpin the ongoing adaptive management of the water source catchment. The present CMP report has been developed as a point of reference to support catchment management activities. Management issues and options identified in the plan were derived from the CMP project risk assessment, literature review, community consultation and catchment modelling.

1.4.7 Health Rivers Commission Inquiries

The Healthy Rivers Commission conducted an inquiry into NSW Coastal Lakes to highlight the need for improved and coordinated management of coastal lakes. The Commission's principal recommendation is that the Government adopts a new comprehensive, and more effective set of over-arching arrangements for the management of coastal lakes and their catchments, through endorsement of the Coastal Lakes Strategy: An Assessment and Management Framework. The recommended Coastal Lakes Strategy builds on recent government decisions and proposals in its Action for the Environment: Environment Statement 2001 and the Coastal Protection Package. A central element of the strategy is the preparation of Sustainability Assessment and Management Plans for coastal lakes, which themselves would constitute key elements of the Comprehensive Coastal Assessment that the Government has initiated. The Coastal Lakes Strategy is an over-arching set of arrangements designed to improve the management (by all relevant parties) of coastal lakes and their catchments so that progress towards the long term goal of healthier coastal lakes is achieved in a timely and cost effective manner. The strategy incorporates:

- Principles for managing coastal lakes,
- A framework for managing major classes of coastal lake,
- A classification of coastal lakes,
- Requirements for preparing and implementing Sustainability Assessment and Management Plans for each coastal lake,

- Implementation arrangements, and
- A range of supporting initiatives.

1.4.8 Northern Rivers Farmland Protection Project

The Farmland Protection Project seeks to protect important farmland from urban and rural residential development by mapping farmland and developing planning principles. The project endeavoured to put forward policies which can be of genuine long-term benefit to agriculture in the region without imposing unnecessary restrictions on farmers.

The project aims to protect a broad range of lands to cater for a range of agricultural industries that may be important currently or in the future, thereby keeping land options open for new crops and farming methods. Urban and rural residential development will be limited on land identified by the project so that areas with the most potential for production are not lost to urban uses.

1.4.9 Far North Coast Regional Strategy 2006 - 2031 (2006)

The Far North Coast Regional Strategy (FNCRS) aims to guide local planning in the six north coast LGAs for the next 25 years and inform decisions on service and infrastructure delivery. The FNCRS identifies priority areas for development for economic and residential purposes over the next 25 years.

1.4.10 Far North Coast Regional Conservation Plan (Draft, 2009)

Within the FNCRS, the Government committed to the development of a Far North Coast Regional Conservation Plan (the RCP). The RCP is a partner document to the FNCRS. The RCP identifies priority conservation outcomes over the period 2006 - 2031. The RCP also provides an offset guide to maximise the conservation of biodiversity over the next 25 years by focusing future offsetting effort to ensure biodiversity values are improved or maintained.

1.4.11 Floodplain Management Plans

The Floodplain Development Manual published in 2005 was prepared in accordance with the NSW Government's Flood Prone Land Policy. It guides councils in the development and implementation of detailed local floodplain risk management plans to produce robust and effective floodplain risk management outcomes.

The floodplain risk management process consists of the following steps:

- Flood Study: Defines the nature and extent of the flood problem, in technical rather than map form.
- Floodplain Risk Management Study: Determines options in consideration of social, ecological and economic factors relating to flood risk.
- Floodplain Risk Management Plan: Preferred options publicly exhibited and subject to revision in light of responses. Formally approved by the council after public exhibition and any necessary revisions due to public comments.
- Plan Implementation: Implementation of flood, response and property modification measures (including mitigation works, planning controls, flood warnings, flood readiness and response plans, environmental rehabilitation, ongoing data collection and monitoring) by Council.

The status of Floodplain Risk Management Plans within the lower Richmond valley is shown in Table 1.

Table 1 – Floodplain Management Plans

Council	River	Urban Centres	Floodplain Risk Planning Status
Richmond Valley	Richmond	Casino	Casino FS – 1988 Casino FRMS & MP - 2002
Lismore City	Wilson	Lismore	Lismore FS & FRMS – 1993 Lismore FRMP – 2001 Lismore FRMP Update – underway-scheduled completion late 2011.
Richmond Valley	Mid Richmond	Tatham, Caraki, Woodburn, Broadwater	Mid-Richmond FS – 1999 Mid-Richmond FRMS – 2002 Mid-Richmond FRMP – 2004 Mid-Richmond Flood Mapping Study - 2010
Ballina Shire	Richmond	Cabbage Tree Island	Cabbage Tree Island FRMP - 2009
Ballina Shire	Richmond	Wardell	Wardell FRMP - 2009
Ballina Shire	Lower Richmond	Ballina	Ballina FS (update) – 2008 Ballina FRMS & FRMP –Underway – scheduled for completion in late 2011.

Note: FS – Flood Study, FRMS – Floodplain Risk Management Study, FRMP – Floodplain Risk Management Plan.

1.5 Planning Instruments

Planning and development in NSW is carried out under the Environmental Planning and Assessment Act 1979 and Environmental Planning and Assessment Regulation 2000. Environmental planning instruments (state environmental planning policies and local environmental plans) are legal documents that regulate land use and development.

Table 2 – State Environmental Planning Policies

Policy	Application to this Study
North Coast REP (1988)	This plan covers all of the North Coast LGAs. It identifies environmental features that are important to the region and provides a basis for new urban and rural development. The plan sets requirements for, and guides, the preparation and processing of local environmental plans and some forms of development.
SEPP Rural Lands, 2008	The aim of this policy is to facilitate the orderly and economic use and development of rural lands for rural and related purposes.
SEPP Remediation of Land, 1998	Councils must ensure contaminated land undergoes remediation before it is developed through the application of land remediation guidelines. The appropriate management and remediation of contaminated sites will minimise the risk of contamination of waterways.
SEPP Building Sustainability Index (BASIX), 2004	BASIX was mandatory for regional NSW from 2005/06. All new residential development, as well as residential alterations and additions, are required to meet targets for water and energy efficiency. This SEPP operates in conjunction with the EP&A Amendment (BASIX) Regulation 2004.

Policy	Application to this Study
SEPP Infrastructure, 2007	Provides a consistent planning regime for infrastructure and the provision of services across NSW, along with providing for consultation with relevant public authorities during the assessment process. The SEPP supports greater flexibility in the location of infrastructure and service facilities along with improved regulatory certainty and efficiency The policy consolidates and updates 20 previous State planning instruments which included infrastructure provisions. It also includes specific planning provisions and development controls for 25 types of infrastructure works or facilities.
SEPP Major Development, 2005	Defines certain developments that are major projects to be assessed under Part 3A of the Environmental Planning and Assessment Act 1979 and determined by the Minister for Planning. It also provides planning provisions for State significant sites. In addition, the SEPP identifies the council consent authority functions that may be carried out by joint regional planning panels (JRPPs) and classes of regional development to be determined by JRPPs. Note: This SEPP was formerly known as State Environmental Planning Policy (Major Projects) 2005.
SEPP 71 Coastal Protection	The policy has been made under the Environmental Planning and Assessment Act 1979 to ensure that development in the NSW coastal zone is appropriate and suitably located, to ensure that there is a consistent and strategic approach to coastal planning and management and to ensure there is a clear development assessment framework for the coastal zone
SEPP 62 Sustainable Aquaculture	Encourages the sustainable expansion of the industry in NSW. The policy implements the regional strategies already developed by creating a simple approach to identity and categorise aquaculture development on the basis of its potential environmental impact. The SEPP also identifies aquaculture development as a designated development only where there are potential environmental risks.
SEPP 44, Koala Habitat Protection	Encourages the conservation and management of natural vegetation areas that provide habitat for koalas to ensure permanent free-living populations will be maintained over their present range. The policy applies to 107 local government areas. Local councils cannot approve development in an area affected by the policy without an investigation of core koala habitat. The policy provides the state-wide approach needed to enable appropriate development to continue, while ensuring there is ongoing protection of koalas and their habitat
SEPP 26 Littoral Rainforests	Protects littoral rainforests, a distinct type of rainforest well suited to harsh salt-laden and drying coastal winds. The policy requires that the likely effects of proposed development be thoroughly considered in an environmental impact statement. The policy applies to 'core' areas of littoral rainforest as well as a 100 metre wide 'buffer' area surrounding these core areas, except for residential land and areas to which SEPP No. 14 - Coastal Wetlands applies.
SEPP 19 Bushland in Urban Areas	Protects and preserves bushland within certain urban areas, as part of the natural heritage or for recreational, educational and scientific purposes. The policy is designed to protect bushland in public open space zones and reservations, and to ensure that bush preservation is given a high priority when local environmental plans for urban development are prepared.

Policy	Application to this Study
SEPP 14 Coastal Wetlands	Ensures coastal wetlands are preserved and protected for environmental and economic reasons. The policy applies to local government areas outside the Sydney metropolitan area that front the Pacific Ocean. Land clearing, levee construction, drainage work or filling may only be carried out within these wetlands with the consent of the local council and the agreement of the Director General of the Department and Planning. Such development also requires an environmental impact statement to be lodged with a development application.

1.6 Local Government Planning Context

Local environmental plans guide planning decisions for local government areas. Through zoning and development controls, they allow councils to supervise the ways in which land is used. Ballina Shire, Lismore City and Richmond Valley Councils have prepared Draft LEPs in accordance with the new standard instrument.

Development control plans, prepared in accordance with the Environmental Planning and Assessment Act, are also used to help achieve the objectives of the local plan by providing specific, comprehensive requirements for certain types of development or locations, e.g. for urban design, and heritage precincts and properties.

1.6.1 Richmond and Brunswick Catchment Model

The Richmond and Brunswick Catchment Model, a three-dimensional Z scale creation representing a river catchment, is a regional education initiative involving Rous Water, Richmond River County Council, Lismore City, Byron Shire, Ballina Shire, Richmond Valley and Kyogle Shire Council.

The model has three running creeks and a river, an estuary and beach to show how the water cycle works, as well as street drains, canals and a sewerage treatment plant to show how reticulated water and waste water also affects the catchment.

The model is contained within a trailer so it can be transported and set up just about anywhere. The project partners will be taking it to schools, local events, markets and field days.

1.6.2 Council Strategic Plans

Strategic plans prepared by the local Councils are discussed in the following tables.

Table 3 – Ballina Shire Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan and Delivery Program	As part of the Department of Local Government's Integrated Planning and Reporting Framework, Council prepared a Community Strategic Plan (CSP) from which a Delivery Program was developed. The Delivery Program provides a summary of the actions Council is undertaking to achieve the CSP Objectives and Outcomes. The Operational Plan outlines the principal activities (i.e. services) to be provided in each year, along with the key service delivery measures that are being recorded to achieve the actions identified in the CSP and the Delivery Program. Relevant Delivery Program actions include: • Provide a proactive approach to Coastline Management to ensure the community is informed and appropriate strategies are in place; • Provide a proactive approach to Flood Management to maximise community safety and knowledge • Provide contemporary stormwater management and infrastructure to minimise environmental impacts • Improve overall health of Richmond River • Continue bush land regeneration work • Progress resource sharing arrangements with other local government authorities to increase efficiencies • Progress Coastal Reserve Planning
Ballina Foreshore Master Plan	The Ballina Foreshore Master Plan builds on existing information on Crown land and Council sites on the Richmond River foreshore located between Burns Point ferry and the Missingham Bridge. The foreshore land includes several large Crown and Council sites and a number of smaller ones that together provide a foreshore asset for the Ballina community. In preparing g the Ballina Foreshore Master Plan each site was assessed in terms of physical and environmental characteristics, existing infrastructure and facilities and planning constraints and opportunities.

Plan	Application to this Study
Ballina Coastal Reserve Precinct Plan	The Ballina Coastal Reserve Plan of Management has been developed for the coastal Crown lands within Ballina Shire north of the Richmond River to the northern Shire boundary. The Ballina Coastal strip consists of 93% Crown land of the immediate coastal foreshore and approximately 85% of all land east of the Coast Road. The preparation of the Plan of Management allowed for the creation of a single Reserve for Public Recreation and Coastal Environmental Protection under section 87 - Crown Lands Act 1989 that is known as the Ballina Coastal Reserve. Ballina Council was subsequently appointed as the Trust manager of this very large Crown Reserve. The Ballina Coastal Reserve Plan of Management was prepared to assist Ballina Shire Council in achieving integrated, balanced, responsible and ecologically sustainable development and management of the Ballina Shire coast. The Precinct Plans are designed to develop the management objectives and recommended management strategies found in the Plan of Management. Precinct Plans are action plans developed at a local level to address social, recreational and environmental issues. The five Precincts delineated in the Plan of Management are: 1. Northern Shire boundary on Seven Mile Beach to Ross Street just south of Lake Ainsworth 2. Lake Ainsworth to Shag Rock (south of Lennox Point) 3. Shag Rock, Boulder Beach, Skennars Head and North Sharpes Beach 4. Flat Rock, Angels Beach and Black Head 5. Shelley Beach, Ballina Lighthouse Beach, Shaws Bay and surrounds.
Vegetation and Land Management in the Maquires Creek Catchment	This report has been prepared for Richmond Landcare Inc. and Ballina Shire Council, in conjunction with Landcare groups in the Maguires Creek catchment, to provide information relating to the current land use, existing native vegetation and environmental restoration projects being undertaken within the catchment.
Shaws Bay Estuary Management Plan	The Management Plan documents the management needs of Shaws Bay and the proposed activities which will address these needs.
Lake Ainsworth Management Plan	The Management Plan develops appropriate management objectives and actions relating to Lake Ainsworth.
Chickiba Lakes Acid Sulfate Soils and Wetland Management Plan, 2006	This Plan assesses and sets out the requirements for management of any site disturbance associated with infrastructure maintenance (mainly drain clearing), wetland rehabilitation works, and other minor works that may impact on Acid Sulfate Soils (ASS) in the Chickiba Lakes area at East Ballina. The aim of this Chickiba Lakes ASS and Wetland Management Plan is to undertake an assessment of the present ASS status of the defined sites, and provide future management recommendations for the Chickiba Lakes area.
Vegetation Management Plans	Ballina Council is in the process of producing Vegetation Management Plans for all the reserves in the Shire that contain native vegetation.
Acid Sulfate Soils Management Plan	Recent changes to Council's local environmental plan now require development consent to be obtained for certain works on lands where there is a potential to expose acid sulfate soils, either by excavation or by lowering the water table.

Plan	Application to this Study
Coastline Management Study	Part one of the Ballina Coastline Management Study (Values Assessment) identifies the ecological, cultural, heritage, recreational and economic values of the Ballina coastline. Part two of the study (Management Options Assessment) identifies where coastal values may be under threat from coastline erosion and outlines various management options.
Wardell and Cabbage Tree Island Floodplain Risk Management Study	This report documents the findings of investigations undertaken to assess a range of potential flood damage reduction measures that could be implemented at Wardell and Cabbage Tree Island. It also documents measures to address emergency response management issues that are likely to exist at Cabbage Tree Island during major flooding of the Richmond River
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.
Lower Richmond River Recreational Boating Study	The Study formulates an integrated short term and long term strategy, comprising strategic options that will address the current and future needs and requirements of recreational boating within the lower Richmond River Estuary, including a program of works and actions to establish Ballina as a premier recreational boating destination and service centre.

Table 4 – Lismore City Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan and Delivery Plan	As part of the Department of Local Government's Integrated Planning and Reporting Framework, Council prepared a Community Strategic Plan (CSP) from which a Delivery Program was developed. The Delivery Program provides a summary of the actions Council is undertaking to achieve the CSP Objectives and Outcomes. The Operational Plan outlines the principal activities (i.e. services) to be provided in each year, along with the key service delivery measures that are being recorded to achieve the actions identified in the CSP and the Delivery Program. Relevant Delivery Program actions include: • Development and implementation of Lismore Biodiversity Management Strategy • Improve catchment management
Acid Sulfate Soil Management	Council has responded to the issue of ASS management through an amendment to its Local Environment Plan and introduction of a Development Control Plan (DCP). The aims of this Plan are to ensure effective management of ASS areas by providing guidance on the procedures involved in managing ASS areas, ensuring activities within an ASS area are identified and requiring soil assessments be undertaken to clarify the extent of risk.
Water Quality and Quantity Policy	This overarching policy applies to all sections within Council having an impact on water quality and stream flows, and contains 3 relevant objectives: • To protect, restore and actively manage the riparian zone • To improve stormwater quality • To improve practices in rural areas

Plan	Application to this Study
Biodiversity – Flora and Fauna Policy	This policy applies to all sections within Council having an impact on native flora and fauna, and contains 3 objectives: • To ensure Council has the information needed to protect and manage native flora and Fauna • To improve the habitat value of remnant and regrowth native vegetation • To foster and promote protection and restoration activities
Land Management Policy	This policy applies to all sections within Council influencing land use and management, and contains 3 objectives. These are: • To create a social and planning environment that reduces conflict and uncertainty in rural zones. • To encourage sustainable land-use practices and partnerships. • To limit landuse changes that diminish scenic amenity.
Heritage Policy	This policy applies to all sections within Council having an impact on cultural and natural heritage. This policy has 3 objectives: • To improve Council's awareness and management of local Aboriginal heritage • To conserve and protect local heritage • To promote and educate the community of the benefits of heritage management
Funding and support for environmental initiatives Policy	This overarching policy applies to all sections involved in implementing the environmental policies of Council, and contains 2 objectives: • To provide adequate funding to enable Council to meet its environmental obligations • To provide adequate information at an appropriate scale to support Council's environmental decision-making.
Restoration of Tucki Tucki Creek recreation Park	Since the purchase of land for the Tucki Tucki Creek Recreation Park in Goonellabah Lismore Council has had an on-going works program to provide recreation facilities, restore vegetation along the creek and improve stormwater devices. Much of this work has utilised Commonwealth job skills programs such as Work for Dole and Greencorps. More recently Council assisted in the formation of a landcare group, made up of local residents, called 'Upper Tucki Tucki Creek Landcare'. Council has received funding under the Estuary Management Program to assist in the ongoing restoration of vegetation along the creek and improve habitat. This funding will also be used to assist the Landcare group with tools and equipment
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.
Stormwater Management Plan	As recommended by the Stormwater Management Plan 2007, Lismore City Council will be implementing a number of practices, programs and policies aim at improving the quality of stormwater flowing from the urban areas. The Stormwater Management Services Charge will allow Council to undertake stormwater management actions that would otherwise remain unfunded.

Table 5 – Richmond Valley Council Strategic Plans

Plan	Application to this Study
Community Strategic Plan	RVC is currently finalising its Community Strategic Plan following community consultation and input into development of the draft Plan.
Evans River Estuary Management Plan	The Estuary Management Plan for the Evans River has been prepared on behalf of the Evans Coastline and Estuary Management Committee, Richmond Valley Council and the Department of Land and Water Conservation, to fulfil the requirements of the NSW Estuary Management Policy (1992) and the NSW Coastal Policy (1997). The Plan provides a program of strategic actions to assist government authorities and other stakeholder groups to sustain a healthy estuary through appropriate waterway, foreshore and catchment management. The Plan presents an integrated suite of management strategies, giving due consideration to the complex interactions between many estuarine processes and functions.
Lower Evans River Dredge Feasibility Assessment	As part of the Evans River Estuary Management Study, an assessment was carried out to determine the feasibility of dredging the lower reaches of the Evans River. The feasibility of dredging sediment from the lower reaches of the Evans River was assessed with the aim of returning the river to former conditions, as much as possible. The dredging proposal considered in this assessment incorporates the removal of sediment from the bed of the Evans River between Iron Gates and the Elm Street bridge.
Richmond River Flood Mapping Report	This study represents the first stage of the floodplain risk management process. The study is the first of three studies aimed at understanding and managing flooding within the Richmond Valley between Casino, Lismore and Broadwater.
Climate Change Adaptation	At the Council meeting of 15 June 2010, Council adopted Scenario 3 to apply to the 2010 base flood modelling. Levels for this scenario have been prepared for the 20, 50, 100, 500 year and PMF design floods. The new flood levels with climate change 3 form the basis for future development. Climate Change Scenario 3: 2010 Base Design Flood Model + 900mm sea level rise + 10% increase in rainfall intensity
State of the Environment Report	SOE reporting is effectively a "Report Card" on the condition of the environment and natural resources. Council prepares these reports each year, as a measure of what initiatives have been undertaken in the local area in response to environmental issues, and to assess new emerging environmental trends.

1.6.3 Richmond River County Council

Richmond River County Council (RRCC) was constituted by proclamation on 25 November 1959 and has been delegated with the responsibility for flood mitigation activities for Ballina, Lismore and Richmond Valley Councils. Council's proclamation was amended most recently on 5 September 2008, when natural resource management was formally incorporated as a Council function.

RRCC provides a coordinating role in floodplain management, working with constituent Councils, State and Commonwealth agencies, university researchers, and floodplain industries to develop long-term effective natural resource management strategies for the Richmond River Floodplain and estuary. Council is responsible for the routine maintenance of its various canals and floodgate structures including the construction and replacement of flood mitigation infrastructure. This includes:

- 76 drainage canals totalling 140km in length.
- 450 flood control structures such as floodgates and culverts.
- 33 levees totalling 77km in length.
- Pump stations used to reduce flooding in Lismore (located at Browns, Hollingsworth and Gasworks Creeks).
- A weir in the Tuckombil Canal 1km south of Woodburn on the Pacific Highway which, (1) prevents the flow of salt water from the Evans River into the freshwaters of the mid-Richmond; (2) prevents Blackwater flows following summer floods from the Richmond impacting on the Evans; and (3) provides flood escape from the mid-Richmond.
- Lismore levee totalling 2km in length - designed to protect Lismore in the event of a 1 in 10 year flood.
- South Lismore levee totalling 5.5km in length - designed to protect South Lismore in the event of a 1 in 10 year flood.

The Richmond Floodplain Committee (RFC) was established by Richmond River County Council with the support of local councils and state agencies in November 2000 to ‘coordinate natural resource management activities and projects on the floodplain in partnership with councils, state government and the community’. The management of natural resources on the estuary and floodplain is presents great challenges and needs long-term community and government support.

Over a number of years the RFC has implemented on-ground works to enhance wetlands, reduce drainage density, monitor water quality and reduce chronic acidification of water ways in dry times through controlled tidal flushing. The RFC also set up the estuary management committee responsible for the implementation of the estuary management planning process for the Richmond River estuary.

Within the principal activities of flood management and mitigation, the Richmond River County Council is currently involved in a wide range of catchment based initiatives, as either the lead agency or in a support/partnership capacity.

1.7 Relevant Legislation

Legislation relevant to the estuary management planning process is discussed in the following table.

Table 6 – Relevant Commonwealth and State Legislation

Legislation	Application to this Study
Commonwealth	
Environment Protection & Biodiversity Conservation Act, 1999	The EPBC Act requires assessment and approval of actions that will potentially have a significant impact on matters of National Environmental Significance. Matters of National Environmental Significance include: • world heritage areas; • wetlands protected by international treaties; • nationally listed threatened species and ecological communities; • nationally listed migratory species; • nuclear actions; and • Commonwealth marine areas.
State	
Environmental Planning & Assessment (EP&A) Act, 1979	The Act requires that environmental assessment is undertaken for all activities. Environmental impact assessments may also be required to satisfy Commonwealth legislation processes. The Act gives the basis for the preparation of environmental planning instruments that may be directly or indirectly related to the water utility businesses. These include State Environmental Planning Policies (SEPP), Regional Environmental Plans (REP), Local Environmental Plans (LEP), Development Control Plans (DCP), Regional and Sub-Regional Strategies.
Local Government Act, 1993	The purposes of this Act are as follows: (a) to provide the legal framework for an effective, efficient, environmentally responsible and open system of local government in New South Wales, (b) to regulate the relationships between the people and bodies comprising the system of local government in New South Wales, (c) to encourage and assist the effective participation of local communities in the affairs of local government, (d) to give councils: • the ability to provide goods, services and facilities, and to carry out activities, appropriate to the current and future needs of local communities and of the wider public • the responsibility for administering some regulatory systems under this Act • a role in the management, improvement and development of the resources of their areas, (e) to require councils, councillors and council employees to have regard to the principles of ecologically sustainable development in carrying out their responsibilities.

Legislation	Application to this Study
Coastal Protection Act, 1979	The objects of this Act are to provide for the protection of the coastal environment of the State for the benefit of both present and future generations and, in particular: (a) to protect, enhance, maintain and restore the environment of the coastal region, its associated ecosystems, ecological processes and biological diversity, and its water quality, and (b) to encourage, promote and secure the orderly and balanced utilisation and conservation of the coastal region and its natural and man-made resources, having regard to the principles of ecologically sustainable development, and (c) to recognise and foster the significant social and economic benefits to the State that result from a sustainable coastal environment, including: (i) benefits to the environment, and (ii) benefits to urban communities, fisheries, industry and recreation, and (iii) benefits to culture and heritage, and (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, and (d) to promote public pedestrian access to the coastal region and recognise the public's right to access, and (e) to provide for the acquisition of land in the coastal region to promote the protection, enhancement, maintenance and restoration of the environment of the coastal region, and (f) to recognise the role of the community, as a partner with government, in resolving issues relating to the protection of the coastal environment, (g) to ensure co-ordination of the policies and activities of the Government and public authorities relating to the coastal region and to facilitate the proper integration of their management activities, (h) to encourage and promote plans and strategies for adaptation in response to coastal climate change impacts, including projected sea level rise, and (i) to promote beach amenity.

Legislation	Application to this Study
Protection of the Environment Operations Act, 1997	The objects of this Act are as follows: (a) to protect, restore and enhance the quality of the environment in New South Wales, having regard to the need to maintain ecologically sustainable development, (b) to provide increased opportunities for public involvement and participation in environment protection, (c) to ensure that the community has access to relevant and meaningful information about pollution, (d) to reduce risks to human health and prevent the degradation of the environment by the use of mechanisms that promote the following: (i) pollution prevention and cleaner production, (ii) the reduction to harmless levels of the discharge of substances likely to cause harm to the environment, (iia) the elimination of harmful wastes, (iii) the reduction in the use of materials and the re-use, recovery or recycling of materials, (iv) the making of progressive environmental improvements, including the reduction of pollution at source, (v) the monitoring and reporting of environmental quality on a regular basis, (e) to rationalise, simplify and strengthen the regulatory framework for environment protection, (f) to improve the efficiency of administration of the environment protection legislation, (g) to assist in the achievement of the objectives of the Waste Avoidance and Resource Recovery Act 2001.
Fisheries Management Act, 1994	The objects of this Act are to conserve, develop and share the fishery resources of the State for the benefit of present and future generations. In particular, the objects of this Act include: (a) to conserve fish stocks and key fish habitats, and (b) to conserve threatened species, populations and ecological communities of fish and marine vegetation, and (c) to promote ecologically sustainable development, including the conservation of biological diversity, and, consistently with those objects: (d) to promote viable commercial fishing and aquaculture industries, and (e) to promote quality recreational fishing opportunities, and (f) to appropriately share fisheries resources between the users of those resources, and (g) to provide social and economic benefits for the wider community of New South Wales, and (h) to recognise the spiritual, social and customary significance to Aboriginal persons of fisheries resources and to protect, and promote the continuation of, Aboriginal cultural fishing.

Legislation	Application to this Study
Crown Lands Act, 1989	The objects of this Act are to ensure that Crown land is managed for the benefit of the people of New South Wales and in particular to provide for: (a) a proper assessment of Crown land, (b) the management of Crown land having regard to the principles of Crown land management contained in this Act, (c) the proper development and conservation of Crown land having regard to those principles, (d) the regulation of the conditions under which Crown land is permitted to be occupied, used, sold, leased, licensed or otherwise dealt with, (e) the reservation or dedication of Crown land for public purposes and the management and use of the reserved or dedicated land, and (f) the collection, recording and dissemination of information in relation to Crown land.
Marine Parks Act, 1977 and Marine Park Regulation, 2009 and Marine Parks (Zoning Plans) Regulation, 1999	The objects of this Act are as follows: (a) to conserve marine biological diversity and marine habitats by declaring and providing for the management of a comprehensive system of marine parks, (b) to maintain ecological processes in marine parks, (c) where consistent with the preceding objects: (i) to provide for ecologically sustainable use of fish (including commercial and recreational fishing) and marine vegetation in marine parks, and (ii) to provide opportunities for public appreciation, understanding and enjoyment of marine parks
Water Management , Act 2000	The objects of this Act are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations and, in particular: (a) to apply the principles of ecologically sustainable development, and (b) to protect, enhance and restore water sources, their associated ecosystems, ecological processes and biological diversity and their water quality, and (c) to recognise and foster the significant social and economic benefits to the State that result from the sustainable and efficient use of water, including: (i) benefits to the environment, and (ii) benefits to urban communities, agriculture, fisheries, industry and recreation, and (iii) benefits to culture and heritage, and (iv) benefits to the Aboriginal people in relation to their spiritual, social, customary and economic use of land and water, (d) to recognise the role of the community, as a partner with government, in resolving issues relating to the management of water sources, (e) to provide for the orderly, efficient and equitable sharing of water from water sources, (f) to integrate the management of water sources with the management of other aspects of the environment, including the land, its soil, its native vegetation and its native fauna, (g) to encourage the sharing of responsibility for the sustainable and efficient use of water between the Government and water users, (h) to encourage best practice in the management and use of water.

Legislation	Application to this Study
Catchment Management Authorities Act, 2003	Northern Rivers Catchment Management Authority is the statutory body created in this Act relevant to the region. CMA activities assist Councils to protect water sources and reduce discharges from urban areas to the catchment. The Act gives the basis for the preparation of a catchment action plan which sets the direction over the next 10 years for investment in natural resource management in the Northern Rivers catchments.
Native Vegetation Act, 2003	The objects of this Act are: (a) to provide for, encourage and promote the management of native vegetation on a regional basis in the social, economic and environmental interests of the State, and (b) to prevent broadscale clearing unless it improves or maintains environmental outcomes, and (c) to protect native vegetation of high conservation value having regard to its contribution to such matters as water quality, biodiversity, or the prevention of salinity or land degradation, and (d) to improve the condition of existing native vegetation, particularly where it has high conservation value, and (e) to encourage the revegetation of land, and the rehabilitation of land, with appropriate native vegetation, in accordance with the principles of ecologically sustainable development
Threatened Species Conservation Act, 1995	The objects of this Act are as follows: (a) to conserve biological diversity and promote ecologically sustainable development, and (b) to prevent the extinction and promote the recovery of threatened species, populations and ecological communities, and (c) to protect the critical habitat of those threatened species, populations and ecological communities that are endangered, and (d) to eliminate or manage certain processes that threaten the survival or evolutionary development of threatened species, populations and ecological communities, and (e) to ensure that the impact of any action affecting threatened species, populations and ecological communities is properly assessed, and (f) to encourage the conservation of threatened species, populations and ecological communities by the adoption of measures involving co-operative management.

Legislation	Application to this Study
National Parks and Wildlife Act, 1989	The objects of this Act are as follows: (a) the conservation of nature, including, but not limited to, the conservation of: (i) habitat, ecosystems and ecosystem processes, and (ii) biological diversity at the community, species and genetic levels, and (iii) landforms of significance, including geological features and processes, and (iv) landscapes and natural features of significance including wilderness and wild rivers, (b) the conservation of objects, places or features (including biological diversity) of cultural value within the landscape, including, but not limited to: (i) places, objects and features of significance to Aboriginal people, and (ii) places of social value to the people of New South Wales, and (iii) places of historic, architectural or scientific significance, (c) fostering public appreciation, understanding and enjoyment of nature and cultural heritage and their conservation, (d) providing for the management of land reserved under this Act in accordance with the management principles applicable for each type of reservation.
Heritage Act, 1977	The objects of this Act are as follows: (a) to promote an understanding of the State's heritage, (b) to encourage the conservation of the State's heritage, (c) to provide for the identification and registration of items of State heritage significance, (d) to provide for the interim protection of items of State heritage significance, (e) to encourage the adaptive reuse of items of State heritage significance, (f) to constitute the Heritage Council of New South Wales and confer on it functions relating to the State's heritage, (g) to assist owners with the conservation of items of State heritage significance.
Noxious Weeds Act, 1993	The objects of this Act are as follows: (a) to reduce the negative impact of weeds on the economy, community and environment of this State by establishing control mechanisms to: (i) prevent the establishment in this State of significant new weeds, and (ii) restrict the spread in this State of existing significant weeds, and (iii) reduce the area in this State of existing significant weeds, (b) to provide for the monitoring of and reporting on the effectiveness of the management of weeds in this State.
Native Title (New South Wales) Act, 1994	The main objects of this Act are: (a) in accordance with the Commonwealth Native Title Act, to validate any past acts, and intermediate period acts, invalidated because of the existence of native title and to confirm certain rights, and (b) to ensure that New South Wales law is consistent with standards set by the Commonwealth Native Title Act for future dealings affecting native title
Soil Conservation Act, 1938	The Act addresses preservation of watercourse environments and the prevention of the destruction of trees and soil erosion on protected land.

Appendix 2: Addendum to the Coastal Zone Management Study for the Richmond River Estuary (Australian Wetlands, 2010)

DRAFT ADDENDUM to the Coastal Zone Management Study for the Richmond River Estuary

For Richmond River County Council

AUSTRALIAN WETLANDS PTY LTD

March 2010

Ref: BB074-2

RICHMOND RIVER COUNTY COUNCIL
Floodplain Management

Project control

Project name: Addendum to the Coastal Zone Management Study for the Richmond River Estuary

Project number: BB074-2

Client: Richmond River County Council
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1 Introduction

As part of the Coastal Zone Management Study for the Richmond River Estuary (CZMS), some further research was undertaken with regard to water quality impacts and monitoring, geomorphological conditions, riparian vegetation conditions and fauna. These data are presented as an Addendum to the CZMS and provide information towards consideration of the management of issues within the identified Management Zones of the Richmond River Estuary.

2 Riparian Vegetation Assessment

2.1 Summary

The riparian vegetation of the Richmond River Estuary is degraded for much of the area. The width of the bank vegetation is often <5 m and few native trees remain. Serious weed invasion is occurring on the banks as there is no natural vegetation to inhibit the growth of weeds. The major weeds are Camphor Laurel and Cockspur Coral Tree.

In some places, particularly North Creek and the lower Estuary, there is some remnant vegetation with good native canopy and mid-storey trees. The understorey is largely dominated by pasture grasses leaving little opportunity for seedling regeneration and nutrient cycling, suggesting that the current vegetation is not providing viable riparian function.

Potential demonstration sites exist in all the management zones. In the Swan Bay, Bungawalbyn, and Kilgin/Buckendoon/Dungarubba management zones potential demonstration sites are at Dungarubba Creek, Oakland Road and Woodburn on the opposite bank to the main town. Good opportunities for revegetation exist around the mouth of Rocky Mouth Creek in Woodburn and with landholders along the creek.

Current Landcare groups are actively involved in riparian vegetation management and enhancement in many of the management zones and Richmond Landcare Inc oversees many of the funded projects. These groups along with private landholder have made notable contributions to riparian vegetation improvements in the study area.

2.2 Background

Riparian vegetation is classified as *vegetation that is found on the banks of a river or stream, and any vegetation on land that adjoins, directly influences or is influenced by a body of water*. Riparian vegetation plays a crucial role in maintaining bank stability and control of bed erosion in streams, which can be directly linked to water quality issues. It can reduce the

amount of sediment and associated pollutants entering the stream. Research suggests that stream and river banks that are sparsely vegetated, erode at a much higher rate than those banks that are densely vegetated (Water Quality Monitoring 2004). A well vegetated streambank is resistant to streambank erosion due to the extra stability provided by the roots and other plant material, and because it can reduce flow velocity at the edges of the stream. Riparian vegetation also plays a role in increasing biodiversity and serves to provide habitat for native fauna. Loss of riparian vegetation, through clearing, livestock grazing or recreational uses, means that these benefits are lost and the overall condition of the stream can decline.

Assessment of vegetation health and the prioritisation of sites was adapted for this study from Owers (2002) and the Rapid Assessment Method (RAM) described in the *Riparian and In-stream Rehabilitation Plan for the Lower Freshwater Reaches of Currumbin Creek* (Australian Wetlands 2006). The assessment has been used successfully on other projects by the project team. This method was a similar but more rigorous assessment method than the one described within the *Tallebudgera Creek Riparian Vegetation Study* (GCCC, 2002).

A broad scale desktop study of aerial photography was used to assess the riparian widths and longitudinal connectivity for the estuary to the tidal limit (Appendix 1). This assessment also provided information on obvious changes in vegetation for on-ground assessment.

The on-ground survey of sites incorporated existing on-ground work sites and areas with potential for high profile demonstration sites for riparian rehabilitation. The desktop assessment was used to assist in identifying suitable sites for on-ground assessment.

Digital photographs were taken at the upstream midpoint of the site facing downstream and downstream facing upstream. Each photo point was noted using GPS coordinates, to identify the extent of the reach.

The field assessment recorded responses to variables in the Riparian Assessment Matrix described below with a brief description of the key features of each site. A list of dominant weed and native species was compiled for each site.

The results of the assessment including GPS locations are contained in a Riparian Assessment Matrix, described in the following section.

2.3 Riparian Rapid Assessment Method (RAM)

Details of the riparian RAM implemented are provided below. Two parameter types were recorded in this assessment, those based on riparian vegetation extent and quality, and those based on rehabilitation potential of the reach and threatening processes on site.

The assessment of condition and extent of riparian vegetation incorporated the following parameters:

1. Longitudinal connectivity (Aerial Photograph Interpretation (API))
2. Width of riparian vegetation (API)
3. Native vegetation cover
4. Site weed control issues
5. Habitat quality assessment

1. **Longitudinal connectivity** measured the length of vegetation >5m wide along the stream for both banks. Four criteria were mapped: 1. Longitudinal connectivity >100m, width 50->100m, 2. Longitudinal connectivity > 100m, width 10-50m, 3. Longitudinal connectivity <100m, width 0-10m, 4. Longitudinal connectivity >100m, width 0-10m.

2. The **width of riparian vegetation** was also assessed from aerial photography and measured. Width was ground-truthed using the flowing criteria: Small Channel < 10 m wide, riparian vegetation width: 0 = <5 m vegetation, 5 = > 5 - <50m vegetated, 10= >100m. Large Channel ≥ 10 m wide: 0 =riparian width (rw)<1/2 channel width (CW), 2 = rw ½ to 1 x CW, 4 = rw 1- 2 x CW, 6= rw 3-4 x CW, 8 = rw 4 x CW., 10=rw10xCW

3. **Native vegetation cover** was measured by a percentage score of overall cover in the canopy and understorey and percentage of native cover in the canopy and understorey. This also gives a corresponding score for % weed cover in the canopy and understorey. Percentage cover and percentage native was classed using the following categories. 0=0, 1=1%, 2=2-10%, 3=11-30%, 4=31-60%, 5=61-100%.

4. **Site weed control issues measured the severity of weeds to indicate the recovery potential of the site.**
   The severity of weeds score (%): High 0 = > 31-100%, Med 5 = 10-30%, Low 10 = <10% or no threat. Dominant weeds in each of the canopy, mid and understorey layers were recorded. Any weeds from the priority weeds list of the Far North Coast County Council (FNCCC), were recorded and the number present on site was used as a rating: score 10 = no priority weeds, 5 = 1 priority weed, 0 = > 2 priority weeds. The priority weeds included the following: Cockspur Coral, Duranta, Groundsel, Water Lettuce, Honey Locust, Hymenachne, Chinese Tallow, Glush Weed, Cats Claw Creeper, Alligator Weed, Chinese Celtis, Water Hyacinth, Camphor Laurel, Salvinia, Broad-leaved Pepper and Alumen Grass.

5. **The habitat quality assessment** measures parameters that identify the values of established riparian habitat for mammals, reptiles and other fauna. The parameters and rating used was:
   - Vegetation community age class 0 = no riparian vegetation or isolated stag trees, 1= seedlings/ planting <5 yo with/without stag trees, 2 = regrowth 10yo, 3 = regrowth >10yo 4 = regrowth with stag trees, 5 =4 old growth >30 yo (Note: stag trees are isolated remnant individuals)

- Tree hollows present, 0 = none, 5 present.
- Leaf litter class, 0 = none, 3 =1-60%, 5 =>60%
- Fallen logs/habitat structure, diversity, 0 =none, 3 = small debris, 5 = abundant
- Seed/fruiting trees: 0 = none, 3 = 1-4 trees, 5 = > 5 trees
- In-stream habitat (in freshwater large woody debris (LWD) or overhang branches etc) Mangrove pneumatophores >1m wide, 0 = none, 3 = <50 % site with habitat features, 5 = > 50 % of site with habitat features.

2.4 Results and Assessment

The on-ground field assessments and general field and mapping observations were used to provide a vegetation assessment overview based on management zones. The assessment results for each site and the site details are described below and the field results are shown in **Error! Reference source not found.** and Table 2.2. The sums of each assessed condition provide a relative indication of the importance of the condition at each site. From these on-ground field assessments and from general field and mapping observations, a vegetation assessment overview based on management zones has been provided.

A list of weed species observed at each Field Site is also provided in Table 2.3. A photographic Archive is provided for each management zone in Appendix 2.

Table 2.1. Longitudinal connectivity, vegetation width and cover assessment of on-ground riparian site assessment. Refer to Section 2.2 for details on scoring.

SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		5	5	**10**		*20m*	**0**	**6**	**6**			4	5		3	2	**14**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		0	0	**0**		*<10m*	0	0	**0**			0	0		5	0	**5**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		5	0	**5**		*>50m*	4	0	**4**			3	4		4	2	**13**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		5	5	**10**		*5m*	5	5	**10**			5	5		5	0	**15**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		0	0	**0**		*<10m*	0	5	**5**			3	5		5	0	**13**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		5	0	**5**			0	0	**0**			3	4		5	0	**12**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		0	5	**5**		*>20m*	0	1	**1**			3	4		3	3	**13**
BC8	Wardell Bridge	28 57' 16.25"S, 153 27' 56.07"E	3	Back Channel		0	0	**0**			0	0	**0**			3	4		4	4	**15**
T	Broadwater	28 59' 50.68"S,	10	Tuckean		0	0	**0**		*>50m*	0	0	**0**			4	4		5	3	**16**

SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
10/11	Road	153 24' 11.22"E																			
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		5	5	**10**		*>20m*	4	4	**8**			5	5		5	4	**19**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin /Buckendoon		0	5	**5**		*>50m*	0	0	**0**			0	0		2	0	**2**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin /Buckendoon		0	0	**0**		*>50m*	0	0	**0**			1	5		5	0	**11**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin /Buckendoon		0	0	**0**		*>50m*	0	0	**0**			2	2		4	1	**9**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		0	0	**0**		*<10m*	0	0	**0**			3	1		5	0	**9**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		0	0	**0**		*>20m*	0	0	**0**			2	4		5	3	**14**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		5	5	**10**		*>20m*	2	0	**2**			4	4		5	4	**17**
UPRW R21/22	Coraki downstream	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/		0	0	**0**		*>20m*	0	0	**0**			2	4		5	0	**11**

SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
	boat ramp			Wilson River																	
UPRW R23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilson River		5	0	**5**		*>20m*	0	0	**0**			4	1		5	0	**10**
UPRW R24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilson River		5	5	**10**		*>20m*	2	2	**4**			4	3		3	0	**10**
UPRW R25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilson River		0	5	**5**		*15m*	0	1	**1**			4	3		5	0	**12**
BU26	Bora Bungawalbyn Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		5	0	**5**		*10m*	5	0	**5**			5	5		4	4	**18**
BU27/ 28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		5	5	**10**		*<10m*	5	5	**10**			4	3		5	0	**12**
UPRW R 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilson River		0	0	**0**		*>15 m*	0	0	**0**			3	5		5	0	**13**

SITE	Site Location	GPS	Management Zone No.	Management Zone name	1. LONGITUDINAL CONNECTIVITY	Bank 1	Bank 2	TOTAL SCORE	2.. WIDTH OF RIPARIAN VEGETATION	*Channel width (CW) m*	Vegetation width (m)	Vegetation width (m)	TOTAL SCORE	3. VEGETATION COVER	*Canopy*	% cover class	% native	*Understorey*	% cover class	% native	TOTAL SCORE
UPRW R31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilson River		5	0	**5**		*20m*	2	0	**2**			4	5		5	0	**14**
UPRW R32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilson River		0	5	**5**		*<5m*	0	0	**0**			4	2		5	0	**11**

Table 2.2 Weed control issues and habitat quality assessment of on-ground riparian site assessment.
Refer to section 11.2 for information on scoring.

SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		10	10	0	5	**25**		2	0	3	0	3	5	10	**23**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		10	10	0	10	**30**		0	0	0	0	0	0	0	**0**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		10	10	0	10	**30**		2	5	3	3	3	3	10	**29**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		10	10	10	10	**40**		4	5	5	5	5	5	0	**29**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		5	5	0	10	**20**		3	5	0	0	3	3	5	**19**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		0	0	0	0	**0**		1	5	0	3	3	5	5	**22**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		5	5	5	10	**25**		2	5	3	3	5	5	10	**33**
BC8	Wardell	28 57' 16.25"S,	3	Back Channel		10	3	10	10	**33**		3	5	3	3	3	3	10	**30**

SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
	Bridge	153 27' 56.07"E																	
T 10/11	Broadwater Road	28 59' 50.68"S, 153 24' 11.22"E	10	Tuckean		10	0	0	5	**15**		4	5	3	3	5	5	10	**35**
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		10	5	0	10	**25**		4	5	3	3	5	5	5	**30**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin/ Buckendoon		0	0	0	5	**5**		0	0	0	0	0	3	5	**8**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin/ Buckendoon		0	0	0	0	**0**		0	0	0	0	3	3	10	**16**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin/ Buckendoon		0	0	0	0	**0**		0	0	3	3	3	3	10	**22**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		0	0	0	0	**0**		0	0	0	0	0	3	5	**8**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		0	0	10	5	**15**		2	5	3	3	3	3	5	**24**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		0	0	0	0	**0**		2	5	3	3	3	5	10	**31**

SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
UPRW R21/22	Coraki downstream boat ramp	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/ Wilson River		10	5	0	0	**15**		1	0	0	0	3	3	10	**17**
UPRW R23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilson River		5	0	0	0	**5**		0	0	0	0	5	3	10	**18**
UPRW R24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilson River		0	0	0	0	**0**		2	5	3	3	3	3	10	**29**
UPRW R25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilson River		10	0	0	5	**15**		3	5	0	3	5	5	10	**31**
BU26	Bora Bungawalbyn Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		0	0	5	0	**5**									
BU27/ 28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		5	0	0	0	**5**									

SITE		GPS	Management Zone	Management Zone name	SITE WEED CONTROL	canopy weeds	mid storey	understorey	FNCC Priority weeds on site	TOTAL SCORE	HABITAT QUALITY ASSESSMENT	Veg community age class	Tree hollows present	Leaf litter class	Fallen logs	Seed/ fruiting trees	In-stream habitat (LWD overhang branches etc)	Habitat connectivity in-stream/ pools/ riffles, water flow	TOTAL SCORE
UPRWR 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilson River		10	5	0	0	**15**		2	5	0	0	3	3	10	**23**
UPRWR31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilson River		10	5	0	5	**20**		2	5	0	3	5	3	10	**28**
UPRWR32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilson River		0	0	0	0	**0**		0	0	0	0	3	3	10	**16**

Table 2.3 Weed species noted in the on-ground site assessment.

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Ageratina adenophora	Crofton Weed																										0
Ageratina riparia	Mist Flower																										0
Ageratum houstonianum	Blue Billy Goat Weed																					X		X	X	X	4
Ambrosia artemisiifolia	Annual Ragweed	X																				X					2
Anredera cordifolia	Madeira Vine							X							X							X			X	X	5
Asclepias curassavica	Redhead Cotton Bush	X																									1
Asparagus aethiopicus	Asparagus Fern	X					X	X																			3
Asparagus plumosus	Climbing Asparagus																X	X		X	X	X	X	X		X	8
Axonopus compressus	Carpet Grass	X	X				X															X					4
Baccharis halimifolia	Groundsel								X																		1
Bidens pilosa	Farmers Friend	X	X	X	X	X						X		X	X						X	X		X	X	X	13
Urochloa mutica	Para Grass		X					X		X	X	X		X	X				X	X							9
Bryophyllum delagoense	Mother of Millions																										0
Cabomba caroliniana	Cabomba																										0
Canna x generalis	Canna Lily							X																			1
Cardiospermum grandiflorum	Balloon Vine									X							X		X	X		X		X	X	X	8
Celtis sinensis	Japanese Hackberry																									X	1
Chloris gayana	Rhodes Grass		X			X	X													X		X					5

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Chrysanthemoides monilifera	Bitou Bush						X																				1
Cinnamomum camphora -	Camphor Laurel	X	X				X		X	X		X	X	X	X	X	X	X	X	X	X	X	X	X		X	19
Cocos plumosus	Cocos	X																									1
Colocasia esculanta	Elephant ears																										0
Commelina benghalensis	Hairy Commelina		X	X			X								X							X				X	6
Conyza albida	Fleabane	X	X																								2
Cuphea carthagenensis	Cuphea																										0
Cynodon dactylon	Common Couch			X	X	X	X			X					X		X	X	X			X				X	11
Desmodium uncinatum	Silverleaf Desmodium																										0
Eichhornia crassipes	Water Hyacinth																X										1
Elodea canadensis	Elodea																										0
Erechtites valerianifolia	Soft Top																										0
Erythrina crista-galli	Coral Tree						X	X		X		X	X	X	X	X	X	X	X	X	X	X	X			X	16
Erythrina sykesii	Coral Tree													X													1
Eugenia uniflora	Brazilian Cherry																										0
Gleditsia tricanthos	Honey Locust																							X			1
Gomphocarpus fruiticosus	Narrow Leaf Cotton Bush																										0
Ipomoea alba	White Ipomea																X			X	X						3
Ipomoea cairica	Coastal Morning Glory	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X		X	X	X	X	X		X	21
Ipomoea indica	Morning Glory							X		X										X						X	4

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Koelreuteria paniculata	Golden Rain Tree																									X	1
Lantana camara	Lantana	X			X	X				X				X	X							X	X	X			9
Ligustrum lucidum	Large Leaved Privet																									X	1
Ligustrum sinense	Small Leaved Privet																			X	X	X			X	X	5
Macroptilium atropurpureum	Siratro									X																	1
Megathyrsus maximus	Guinea Grass																										0
Melinis minutiflora	Molasses Grass																										0
Morus alba	Mulberry																			X		X			X	X	4
Myriophyllum aquaticum	Parrots Feather																										0
Nymphaea capensis	Cape Waterlily																										0
Nymphaea zanzibarensis	Water Lilly																										0
Ochna serrulata	Ochna																										0
Oxalis sp.	Oxalis																										0
Paspalum dilatatum	Paspalum																										0
Paspalum sp.	Paspalum Grass																										0
Paspalum urvillei	Vasey Grass	X	X	X		X	X						X	X	X	X				X		X					11
Paspalum wettsteinii	Broad-leaved Paspalum									X												X					2
Passiflora subpeltata	White Passionfruit	X																									1
Pennisetum alopecuroides	Swamp Foxtail																X										1
Pennisetum clandestinum	Kikuyu Grass		X			X	X						X		X		X			X	X	X					9

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Pennisetum sp.	Bana Grass																										0
Persica sp.	Peach																										0
Phyllostachys aurea	Golden Bamboo																										0
Psidium guajava	Yellow Guava																				X						1
Ricinus communis	Castor Oil												X							X				X	X		4
Rivina humilis	Coral Berry														X				X	X						X	4
Salvinia molesta	Salvinia																										0
Schefflera actinophylla	Umbrella Tree																										0
Schinus terebinthifolius	Broad-leaf Pepper Tree																								X		1
Senecio madagascariensis	Fireweed																										0
Senna pendula var. glabrata	Easter cassia	X		X	X	X	X	X		X				X	X											X	10
Setaria sphacelata	Setaria												X	X	X	X				X	X	X					7
Sida rhombifolia	Paddy's Lucerne													X	X	X						X	X				5
Solanum mauritianum	Wild Tobacco																					X					1
Solanum seaforthianum	Blue Potato Vine									X										X							2
Sorghum halepense	Johnson Grass																		X	X		X		X			4
Sphagneticola trilobata	Singapore Daisy							X																			1
Tagetes minuta	Stinking Roger																										0
Tecoma stans	Yellow Tecoma																					X					1
Tradescantia albiflora	Wandering Jew									X								X		X		X				X	5

		NC1	NC2	EC3	SB4	SB5	SB6	SB7	BC8	T11	T12	KB14	KB15	KB18	RC17	E19	SB20	BU28	UPRWR21	UPRWR23	UPRWR24	UPRWR25	UPRWR26	UPRWR30	UPRWR31	UPRWR32	Sites present
Trifolium repens	White Clover	X																									1
Vachellia farnesiana	Mimosa Bush																	X									1

Zone 1 - North Creek/Newrybar

On-ground sites NC1, NC2

The riparian vegetation along North Creek was mostly greater than 50m wide with a high native cover in the canopy (>30% - 60%). The dominant species in the lower estuarine zones were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) at the water's edge.

The Ballina Nature Reserve covers a large section of North Creek. Extensive saltmarsh areas were found in the lower reaches of the creek. Although the canopy weed cover was low, the understorey weed cover was >90% in some areas. Threatening weeds include Ground Asparagus (*Asparagus aethiopicus)* with vines such as Coastal Morning Glory (*Ipomoea cairica*) and White Passionfruit (*Passiflora subpeltata*). These weeds were preventing regeneration in the understorey and reducing habitat for reptiles. These reaches have a high recovery potential if weeds and pasture grasses were controlled as there was an abundant seed source available for regeneration.

In the higher reaches above Ross Lane, the Creek has been channelized by historical drainage union works. With the exception of pasture grasses and a few patches of regrowth upstream, riparian vegetation is almost non-existent on the channel. The current landuse, predominantly cane farming, limits expansion of the riparian vegetation along this part of the creek.

Zone 2 - Emigrant/Maguires Creek

On-ground sites EC3

The lower estuarine areas of Emigrant Creek have good mangrove areas. The riparian width varies from wide 50m to <10m where landuse or roads come close to the creek edge. The dominant species were similar to North Creek with Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, and mangroves such as Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) dominating the water's edge. The major issues for riparian management in this area were urban and infrastructure encroachment and recreational landuse (e.g. vehicles causing damage to saltmarsh and creek banks).

Zone 3 - Back Channel

On-ground sites BC8

The Back Channel management zone includes the riverbank near Wardell. The northern bank of the river has a healthy mature (>10yo) corridor of mangroves and riparian vegetation with 30-60% native cover in the canopy and understorey. On the southern side, the riparian vegetation was very narrow to non-existent in places. Priority weeds were not evident. The

riparian vegetation on the southern side includes remnant mangroves and saltmarsh. The major issues affecting the recolonisation of mangroves are boat wash and encroaching landuse.

Zone 4 - South Ballina/Empire Vale

On-ground sites SB4, SB5, SB6, SB7

The South Ballina management area includes the Ballina Nature Reserve along South Ballina Beach Road. Mangroves were extensive in this reach. Several large floodgates feed into the river along the zone. The flood-gated area at Empire Vale has been identified as a potential riparian rehabilitation site as it is a refuge area for fish in flood times. The dominant canopy vegetation was Forest Red Gum (*Eucalyptus tereticornis*) and Hoop Pine (*Araucaria cunninghamii*), with mangroves along the main channel. The riparian vegetation was less than 30% cover but predominantly native with few weeds. Major weeds were Coastal Morning Glory (*Ipomoea cairica),* Lantana *(Lantana camara)* and Senna *(Senna pendula var. glabrata),* with pasture grasses and herbs such as Farmers Friend *(Bidens pilosa).* The riparian zone along the river was approximately 50m wide in this area, but became narrower to non-existent towards the locality around Keith Hall Road.

Native tree planting at Carney Lane was becoming established but further planting and weed control will be required. On the western bank, near Pimlico Island, a very narrow native riparian zone is threatened by weeds, particularly vines like Coastal Morning Glory (*Ipomoea cairica).*

Major issues for riparian management centre on boat wash and loss of native vegetation to weeds, as well as encroaching urban, agricultural and infrastructure landuses.

Zone 5 – Rileys Hill

This is a relatively small management zone with boat launch facilities, urban dwelling and agriculture (predominantly sugar cane). The riparian vegetation varied from some coverage (riparian width >10m) with some remnant native vegetation near to very limited. The dominant species along banks were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). Common Reed (*Phragmites australis*) and Cumbungi (*Typha orientalis*) provide habitat along the bank toe in places. The understorey vegetation was degraded with few native species. Landuse activities and road infrastructure were encroaching on the riparian zone.

Other issues for riparian management were boatwash and clearing of the existing vegetation. The opportunities for improvement of riparian vegetation in this management zone are varied and depend on site access and landuse limitations. Brolgas were observed in grazing paddocks in this zone.

Zone 6 - Evans River

On-ground sites E19

Vegetation along the Evans River is extensive in some areas but around the Tuckombil Canal, downstream of the Pacific Highway, there is no riparian canopy. Upstream of the Pacific Highway, the dominant canopy tree was Forest Red Gum (*Eucalyptus tereticornis*) along with Swamp Oak (*Casuarina glauca*) and Hoop Pine (*Araucaria cunninghamii*). There were no mid-storey species. Water couch (*Paspalum distichum*) colonised the edges of the banks.

The major weed species was Cockspur Coral Tree (*Erythrina crista-galli*). There is opportunity to manage bank erosion around the Tuckombil Canal using low riparian vegetation that can tolerate inundation. Revegetaion would require landholder support or need engagement with the RTA during the construction of the new route of the Pacific Highway.

RRCC has recently had a report completed on the management of the Tuckombil Canal and they have resolved to place the Tuckombil Canal Management Report on public exhibition and proceed to public consultation on the basis of a fixed weir.

Zone 7 - Rocky Mouth Creek

On-ground sites RC17

The vegetation along the riparian zone of Rocky Mouth Creek was dominated by a weedy canopy of Cockspur Coral Tree (*Erythrina crista-galli*). Camphor Laurel (*Cinnamomum camphora*) was also a major canopy weed along Rocky Mouth Creek. The canopy cover was less than 30% with almost no native species. The existing remnant native canopy vegetation included some Forest Red Gum (*Eucalyptus tereticornis*), with Black Tea-tree (*Melaleuca bracteata)* in the mid-storey. The toe of the bank was colonised by native species such as *Bolboschoenus* sp. and Common Reed (*Phragmites australis*). Pasture grasses dominated the understorey. Other major weeds included Senna *(Senna pendula var. glabrata)* and Madeira Vine (*Anredera cordifolia*).

Good opportunities for revegetation exist around the mouth of Rocky Mouth Creek in Woodburn and with landholders along the creek.

Zone 8 - Swan Bay

On-ground sites SB20

Riparian vegetation on the northern bank of Swan Bay extending to the start of Swan Bay Road, was dominated by native riparian species. The canopy cover was over 30% and up to 60% with a high percentage (60%) of native species. The dominant native canopy was Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*). The major mid-storey species included the threatened species Sweet Myrtle (*Gossia fragrantissima),* and more common Green Native Cascarilla *(Croton verreauxii)* and Foambark *(Jagera pseudomes).* The understorey

vegetation was heavily grazed by cattle and was dominated by pasture grasses and native species such as Basket Grass (*Oplismenus undulatus*) and Swamp Foxtail (*Pennisetum alopecuroides*). Smartweed (*Persicaria stigosa*), Cumbungi (*Typha orientalis*) and *Bolboschoenus* sp. colonised the edges of the oxbow.

Serious weeds were evident in the Swan Bay area. Water Hyacinth (*Eichhornia crassipes*) covered less than 10% over the water surface. This lower coverage was possibly due to control measures or flooding and flushing of the Oxbow. Cockspur Coral Tree (*Erythrina crista-galli*) was the main canopy and mid-storey weed. Several vines were encroaching on the remnant vegetation. These were Coastal Morning Glory, (*Ipomoea cairica*), White Morning Glory (*Ipomoea alba*), Climbing Asparagus (*Asparagus plumosus*) with large areas of Balloon Vine (*Cardiospermum grandiflorum*).

The Swan Bay region has major potential for rehabilitation. Existing remnant vegetation provides a useful reference community for edge plantings. Control of aquatic weeds will allow the oxbow to function as a valuable wetland for resident and migratory birds. Grazing may be used as a weed control method but at a lighter regime than the present one.

Zone 9 - Kilgin Buckendoon

On-ground sites KB14, KB15, KB18

The riparian vegetation of the Kilgin Buckendoon management zone varied from some coverage (riparian width >10m) with remnant native vegetation near Dungarubba Creek, to highly degraded near Kilgin Drain and along the channel to Woodburn. The native canopy cover was < 10% for most of this area of the channel.

The dominant species along banks were Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). Hoop Pines (*Araucaria cunninghamii*) were also noted in the riparian zone and close to the water's edge in some places. Common Reed (*Phragmites australis*) and Cumbungi (*Typha orientalis*) provide habitat along the bank toe in places. The understorey vegetation was degraded with few native species. The dominant landuse throughout this area was cane farming with some Macadamia plantations and cattle grazing. Landuse was impacting on riparian vegetation in some places.

Cockspur Coral Tree (*Erythrina crista-galli*) appears to be increasing and was the dominant canopy weed along this riparian management zone. Other dominant weeds were Castor Oil Plant (*Ricinus communis*), and Para grass (*Urochloa mutica*), along the bank edges.

Other issues for riparian management were boatwash and current clearing of the existing vegetation. The opportunities for improvement of riparian vegetation in this management zone were high as there was existing remnant vegetation to provide structural cover and seed sources. The bank has high visibility and good access for works although in places the extent of

rehabilitation works will be limited by road infrastructure. Potential demonstration sites exist at Dungarubba Creek, Oakland Road and Woodburn on the opposite bank to the main town.

Zone 10 - Tuckean

On-ground sites T11, T12

Sites surveyed in the Tuckean covered the Baggotville Barrage to the mouth of the riverbank and along the Broadwater Road. The riparian vegetation in the Tuckean was often greater than 50m wide with a high native cover in the canopy (>-60% - 100%). Upstream of the Barrage, the Tuckean Nature Reserve covers a large area and mangroves were noted to be recolonising the upstream area. The vegetation downstream of the barrage was diverse with fresh and saltwater species co-existing. The dominant species along banks were Broad-leaved Paperbark (*Melaleuca quinquenervia*), Swamp Oak (*Casuarina glauca)* and Tuckeroo (*Cupaniopsis anacardioides*) on the banks, with mangroves including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*). The understorey vegetation along the banks included Water Ribbons (*Triglochin procera*), Cumbungi (*Typha orientalis*), River Lily (*Crinum pendunculatum*) and Sea Rush (*Juncus kraussii*). An extensive cover of Cape Waterlily (*Nymphaea capensis*) was evident both up and downstream of the Barrage. The vegetation downstream of the barrage provides significant estuarine habitat and should be highly valued.

The riparian vegetation along the main channel near Broadwater Road was highly diverse but narrow and threatened by climbing weeds in places. The main canopy tree was Forest Red Gum (*Eucalyptus tereticornis*) with Tuckeroo (*Cupaniopsis anacardioides*) on the banks. Mangroves, including Grey Mangrove (*Avicennia marina*) and River Mangrove (*Aegiceras corniculatum*) and Common Reed (*Phragmites australis*) were colonising the toe of the bank in many places. The riparian vegetation included remnant rainforest species such as Hard Quandong (*Elaeocarpus obovatus*), Green Native Cascarilla (*Croton verreauxii)*, Clerodendron (*Clerodendron floribundum),* Rapanea *(Myrsine variabilis)* and *Exocarpus latifolius.*

Several water weeds, transported to the site by flood waters, were evident near the bank. These were Parrots Feather *(Myriophyllum aquaticum*), Water Hyacinth *(Eichhornia crassipes),* Salvinia *(Salvinia molesta),* Water Lettuce *(Pistia stratiotes*), Duckweed (*Lemna* sp). and *Azolla* sp*.* The rotting biomass of these weeds in the brackish conditions of the estuary may present potential blackwater and low dissolved oxygen issues.

Zone 11 - Lower Bungawalbyn

On-ground sites BU26/27/28

The results of committed riparian management were evident in the riparian vegetation of the Bungawalbyn catchment. Weed control around the mouth of Bora Creek and along Bungawalbyn Creek has been successful. The width of the riparian zone was less than 10 m for much of the area but the riparian canopy cover was over 60-100%. The percentage of native species in the canopy was over 90%. The riparian vegetation was fenced with an electric fence

for cattle at the study site. The weed species that were present in low abundance were seedlings and mature plants of Climbing Asparagus (*Asparagus plumosus)*, Cockspur Coral Tree (*Erythrina crista-galli*) and Coastal Morning Glory Vine (*Ipomoea cairica*) was evident in places.

Weed control and planting along Sandy Creek has also been successful with a canopy cover of up to 60% native and a high diversity evident. The major canopy species was Forest Red Gum (*Eucalyptus tereticornis*), with Whalebone Tree (*Streblus brunonianus*), Rough-leaved Elm (*Aphananthe philippinensis*), and Sally Wattle (*Acacia melanoxylon*). The River Lilly (*Crinum pendunculatum*), Marsh Club-rush (*Bolboschoenus fluviatilis*) and Creek Mat Rush (*Lomandra hystrix*) were colonising along the toe of the bank. The high diversity on the Bungawalbyn provides important reference sites for future riparian rehabilitation. There is scope for further riparian rehabilitation activities in this area.

The dominant weed species in this zone was Mimosa Bush (*Vachellia farnesiana*).

The Bora Creek Management Plan has recently been completed and will assist with weed management and riparian revegetation strategies.

Zone 12 - Upper Richmond/Wilsons River

On-ground sites UPRWR21/22, UPRWR23, UPRWR24, UPRWR25, UPRWR26, UPRWR30, UPRWR32, UPRWR32

The Upper Richmond and Wilsons River estuary management zone includes Leycester Creek, the Wilsons River from Lismore to Coraki and the Richmond River from Casino to Coraki.

Leycester Creek is mainly cleared of riparian vegetation with some remnant areas near site UPRWR25. The remaining vegetation in this section is dominated by River Oak (*Casuarina cunninghamiana*) and Weeping Bottlebrush (*Callistemon viminalis*) with rainforest elements in the mid-storey. The dominant mid-storey species include Whalebone Tree (*Streblus brunonianus*), Red Kamala (*Mallotus philippensis*) and Cudgerie (*Flindersia schottiiana*). The understorey was dominated by pasture grasses and herbaceous weeds with some native grasses, including Basket Grass (*Oplismenus* spp.). The threatened species Thorny Pea (*Desmodium acanthocladum*) was also found. The toe of the bank was largely unvegetated but *Baumea articulata* and other sedges were colonising in a few places. This site has high regeneration potential with a percentage cover class of up to 60% in the canopy with 30% native species. The major weed species in the canopy were Mulberry (*Morus alba*), Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*), which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*). Bank exposure in places was severely impacting erosion of the bank and causing slumping in places. Vegetation has been compromised.

Wilsons River upstream of Lismore

The riparian vegetation along the Wilsons River above Lismore at the Trinity Sports Field, was dominated by a canopy of Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina sykesii*). The native canopy cover was less than 10%, consisting of Silky Oak (*Grevillea robusta*) and Red Kamala (*Mallotus philippensis*). Several native species were present in the mid and understorey, including Whalebone (*Streblus brunonianus*), Small-leaved Tuckeroo (*Cupaniopsis parvifolia*), Rough-leaved Elm (*Aphananthe philippinensis*), Twin-leaved Coogera (*Arytera distylis*) with the threatened species, Thorny Pea (*Desmodium acanthocladum*). The major weeds were Madeira Vine (*Anredera cordifolia*), Coral Berry (*Rivina humilis*) and Senna (*Senna pendula*).

Wilsons River downstream of Lismore

Downstream from Lismore, the Wilsons River riparian corridor was sparse with a canopy cover of less than 10% in many places. The dominant native species were Forest Red Gum (*Eucalyptus tereticornis),* Weeping Bottlebrush *(Callistemon viminalis)* with some River Oak (*Casuarina cunninghamiana).* The percentage of native species in the canopy varied between 1% and 30%. The major weed species in the canopy were Mulberry (*Morus alba*), Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*) which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*). Other serious understorey weeds included Para Grass (*Urochloa mutica*) and Johnson Grass (*Sorghum halepense*).

Upper Richmond River

The riparian corridor along the Richmond River to Casino was similar to the Wilson River. The dominant native species were Forest Red Gum (*Eucalyptus tereticornis),* Weeping Bottlebrush *(Callistemon viminalis)* with some River Oak (*Casuarina cunninghamiana).* Other native trees included Creek Lilly Pilly (*Acmena smithii*) and Twin-leaved Coogera (*Arytera distylis*) .The percentage of native species in the canopy varied between 1% and 30%. The understorey was dominated by pasture grasses and herbaceous weeds with some native grasses including Basket Grass (*Oplismenus* spp.). The major weed species in the canopy were Mulberry (*Morus alba*) Camphor Laurel (*Cinnamomum camphora*) and Coral Tree (*Erythrina crista-galli*), which all pose a serious threat to the remaining native species if left uncontrolled. Other serious weeds on the site were Balloon Vine (*Cardiospermum grandiflorum*), Climbing Asparagus (*Asparagus plumosus*) and Coastal Morning Glory (*Ipomoea cairica*).

Other serious understorey weeds included Para Grass (*Urochloa mutica*) and Johnsons Grass (*Sorghum halepense*). This area is reported to have Honey Locust (*Gleditsia tricanthos*) and *Hymenachne* sp. which are both potentially serious invasive weeds of the lower estuary in the future.

The Richmond River at Casino has similar vegetation although some very useful regeneration work has been completed. This site has high potential as a focus site for revegetation works to demonstrate the appropriate species for slowing bank erosion.

3 Geomorphological Assessment

3.1 Summary

The issues occurring within each of the 12 management zones are primarily the direct consequence of anthropogenic activity which began with permanent European settlement of the Richmond River Basin from around 1842. Extensive land clearance, initially for the timber industry, but also to facilitate the establishment of broad scale farm based agricultural enterprises has set the scene for an altered landscape which is more susceptible to fluvial erosion processes in a high rainfall region.

The cumulative effects of a largely cleared landscape are most evident along the steeper slopes of upper catchments and the upper to mid floodplain where erosion scarps and bank slumping are common in areas no longer bordered by natural riparian vegetation. Mass movement of eroded sediment is most evident in the lower floodplain where siltation and infilling of channels has progressively restricted navigation for boating and exacerbated the spread of floodwaters following high rainfall events.

Drainage modification for farming (particularly sugar cane), roads and flood mitigation measures have had a marked effect on the natural flow regime. In these areas, there is no longer the capacity for streams to establish natural meanders in response to landscape gradients and natural rates of flow. Consequently, drainage patterns are established to suit farming practices and in addition to hydrologic changes, can promote erosion of fallowed soil during high rainfall events, direct to the main river system.

The major management issues for the Richmond River Floodplain are highlighted in the summary table (Table 3.5) which shows sheet and rill erosion, drainage modification for agriculture, water course obstructions, and a lack of suitable riparian vegetation (within at least one portion of each zone) as the common elements across all Management Zones. The establishment of suitable vegetation for riparian corridors and natural vegetation for stabilisation of denuded banks would result in a significant reduction in bank erosion and sediment displacement.

3.2 Context of the Richmond River Estuary and Catchment

The geology of the Richmond River catchment is comprised primarily of Tertiary-Quaternary Sediments (river gravels, alluvium, sand and clay as well as beach and dune sands) and Tertiary Volcanics (Lismore Basalt) which overlay Palaeozoic Neranleigh-Fernvale Metasediments. In addition, there are several scattered outcrops of Mesozoic sediments, including the Walloon Coal Measures, Kangaroo Creek Sandstone and the Tabulam Group (Redcliff Coal Measures).

These Mesozoic sediments include rock types such as sandstone, siltstone, claystone, shale, conglomerate and coal (Brunker *et al*. 1972; Hanlon *et al*. 1970).

The five main soil types in the catchment are; red basaltic (kraznozem), chocolate, alluvial, podzolic and coastal heath soils. The red and chocolate soils have developed from Tertiary Basalts in elevated areas of high rainfall, the podzolic soils have developed from Mesozoic Sediments and the coastal heath soils have formed from Quaternary Sediments. Alluvial soils contain sediments from all geologic groups (Donnelly, 1997).

The Richmond River catchment covers an area of approximately 6900 km^2 which includes three main tributaries, the Wilsons River, the Richmond River and Bungawalbyn Creek (Hossain *et al*. 2002) and the floodplain (Donnelly 1997). Approximately 20% of the catchment has slopes exceeding 15°; 40% has slopes between 3° and 15°; with the remaining area comprised of flat land with extensive floodplains (WBM 2006; Hossain *et al*. 2001). Only 22% of the Wilsons River subcatchment is forested, compared with 42% of the Richmond River and 75% of the Bungawalbyn Creek sub-catchments (Hossain *et al.* 2002).

With the exception of the Bungawalbyn Creek subcatchment and the Border Ranges, the majority of the Richmond catchment has been extensively cleared of native vegetation with a significant number of natural water courses (tributaries) having been highly modified for agricultural drainage and/or flood mitigation purposes. Changes in the landuse patterns such as deforestation and agricultural activities in the upper catchments, development on the lower floodplains, and urbanisation in the lower coastal catchments, has significantly increased the supply of sediment to the river system (Hossain *et al*. 2004). Landuse, population density, geology and soils vary considerably across the catchment (McKee *et al*. 2001), and landuse changes in the subcatchments indicate a potential increase of suspended sediment load of about 6-fold since European settlement (Hossain *et al*. 2002).

Loose rock protection is present along most of the Richmond riverbank as far upstream as Wardell. Upstream from Wardell, bank erosion contributes substantially to downstream sediment loading. On the lower Richmond River floodplain, bank erosion does not significantly contribute to the sediment supply, nor do tributary streams other than for fine clays and silts during high rainfall run off events. The main contributors to bank instability are boat wake and locally generated wind waves (WBM 2006).

The straightening of existing river or tributary meander in areas of where drainage regimes have been altered, results in heightened erosion of banks, as it steepens the gradient of the channel and thus increases water velocity (Ladson 2008). The natural meander of water courses has been largely disregarded by agricultural land management practices, leading to significant increases in sediment transport downstream.

The catchment is characterised by net seaward-directed sediment transport, associated with the predominantly high river discharge and relative absence of available accommodation space

for sediment deposition (WBM 2006). Consequently, fine suspended sediment, and coarse sediment (as bed-load), is moved downstream along the bottom of the deltaic channels, due to unimpeded river flow. Where flow is impeded by built structures such as weirs and dams, sediment becomes trapped under normal flow regimes and there is often significant infilling from sediment build up.

The Richmond River Estuary can be described as a bar built, micro-tidal, mature wave dominated delta (Roy *et al*. 2001; Hossain *et al*. 2004; Hashimoto et al. 2006). The tidal influence extends to Boatharbour in the Wilsons River, to Casino in the Richmond River and 15km upstream in Bungawalbyn Creek (Hossain *et al*. 2001). Fine and coarse sediment enters the estuary from the catchment, subject to climatic conditions and the volume of river input. Seasonal and climate factors dominate the function of deltas, with episodic high-flow events causing intense flushing, sedimentation, and erosion in the main channels and floodplain (Eyre *et al*. 1998).

Suspended sediment transport through the estuary is controlled by many factors including river flow, tidal flows, tidal range, salinity, density, circulation and wind (Hossain *et al*. 2004). Freshwater discharge appears to be a major influence on sediment transport, deposition and export to the continental shelf (Hossain *et al*. 2001). Increasing amounts of sediment being received by estuarine ecosystems is increasing the economic burden on local communities as high standards of water quality are expected and there are escalating costs to remove sediment and maintain channels for navigation and flood mitigation purposes (Eyre *et al*. 1998).

3.3 Methodology for Field Site Assessment

3.3.1 Geomorphic Stability Assessment

Methodology developed by Rosgen (1996) and adapted after Dilworth (2008), was used to assess geomorphic stability at the same sites the vegetation assessment was carried out. Scores were given that related to stability characteristics, shown in Table 3.1, at the same sites where the vegetation assessment was complete.

Table 3.1. Scoring system used to assess geomorphic stability.

Stability	*Characteristics*	*Score*
Stable	Geomorphic structures of the channel unaltered or largely unchanged from pre-European disturbance state, and geomorphic form processes (sediment transport) are in equilibrium with existing channel geometry. High sediment transport competence. Usually bedrock controlled and not subject to or likely to be subject to bed level adjustment.	10-8
Moderately Unstable	Stable convex stream banks with intact bank toes stable. Isolated incidences of bed and bank erosion may be present but can easily be addressed by restoring riparian vegetation, and bank protection.	8-5
Unstable	Both bed level and/or lateral adjustments are active in-stream. Vertical stream banks indicate major bank erosion, which is associated with active bed level adjustments (minor head cuts) are common.	5-3.5
Highly Unstable	The channel is entrenched and highly unstable with ongoing vertical and/or lateral bed and bank erosion. Stream banks are vertical to concave and numerous bed level adjustments are evident.	3.5-0

3.3.2 Geomorphic Condition

Methodology developed by Lambert *et al*. (1999) and adapted after Dilworth (2008), was used to define the geomorphic conditions of each site assessed. The scoring was based on the conditions described in Table 3.2.

Table 3.2 Condition assessment used to classify the geomorphology.

Geomorphic Condition	*Characteristic*	*Score*
Near Intact	The geomorphic structure is largely unchanged from pre-disturbance state. Riparian vegetation is usually unchanged. Geomorphic form characteristics and processes are in equilibrium. The aquatic waterway is providing critical aquatic habitat refuge.	10-8
Good	Geomorphic structure is largely unchanged from pre-disturbance state, however, vegetation cover and composition may be significantly altered. Characteristics and processes are in equilibrium. The aquatic waterway is providing critical aquatic habitat refuge.	8-6.5
Moderately impacted	Geomorphic form characteristics and processes have been disturbed in the past and remain out of equilibrium. The waterway has not adjusted to prevailing conditions and is experiencing on-going changes. Aquatic habitat refuge is still provided however the condition is degraded.	6.5-4.5
Degraded	The channel has become entrenched laterally and vertically expanded to its most degraded condition. The channel is disconnected from the floodplain. Geomorphic form and characteristics are processes are degraded. Limited aquatic refuge habitat is provided.	4.5-0

3.3.3 Geomorphic recovery potential

Methodology developed by Lambert et al. (1999) and after Dilworth (2008), was used to determine a score for recovery potential. Table 3.3 outlines the characteristic used in the scoring.

Table 3.3 Scoring system used to assess recovery potential at sites.

Recovery Potential	*Characteristics*	*Score*
Conservation	River structure and vegetation associations are relatively intact. Management strategies should aim to maintain, or improve the current River Style.	10-8
Strategic	Sites or reaches which are sensitive to disturbance triggering upstream geomorphic degradation, lateral or vertical expansion of the channel. These areas may deliver an oversupply of sediment to downstream reaches. Proactive management strategies are the most effective means of conservation. Attention should be placed on bed level adjustments.	8
High Recovery	These reaches have high inherent natural recovery potential and will respond well to improved land management and assisted regeneration.	8-6
Moderate Recovery	These moderately degraded sites/reaches have reasonable potential to recover and can be rehabilitated at reasonable cost. River structure and vegetation associations require improvement. Bed and bank rehabilitation strategies may be required to stabilise the waterway.	6-4
Degraded reaches	These highly degraded sites/reaches have little natural recovery potential (i.e. the water way shows signs of continued geomorphic degradation). Extensive bed and bank stabilisation works are required at considerable cost over a long period of time.	4-0

3.4 Results and Assessment

The observations made during a catchment tour together with a literature review and the results of the on-ground site assessment, were used to provide a geomorphic status assessment for each management zone. The results of the on-ground site assessment are provided in Table 3.4.

Additionally, photograph Archives for each management zone and at specific on-ground sites are presented in Appendix 2.

Table 3.4 Geomorphic Assessment Scoring.

SITE		GPS	Management Zone Number	Management Zone name	BANK AND BED STABILITY	Geomorphic stability	Creek and Bank Condition	Recovery Potential	TOTAL SCORE
NC1	Nth Cr Road	28 50' 21.21"S, 153 34' 43.26"E	1	North Creek		5.5	5.5	7.5	**18.5**
NC2	Upstream Ross Lane	28 47'12.76"S, 153 33' 50.14"E	1	North Creek		5.5	5.5	7.5	**18.5**
EC3	Emigrant Cr	28 50' 01.53"S, 153 30' 48.50"E	2	Emigrant/ Maguires		5.5	5.5	7.5	**18.5**
SB4	Sth Ballina Beach Road	28 52' 52.62"S, 153 33' 34.82"E	4	Sth Ballina		5.5	5.5	7.5	**18.5**
SB5	Empire Vale	28 54' 46.58"S, 153 30' 30.60"E	4	Sth Ballina		5.5	5.0	6.0	**16.5**
SB6	Carney Lane River Dr	28 57' 6.07"S, 153 28' 29.80"E	4	Sth Ballina		6.0	5.5	5.5	**17.0**
SB7	Near Pimblico Is	28 54' 49.43"S, 153 29' 19.35"E	2	Emigrant/ Maguires		4.5	5	4.5	**14.0**
BC8	Wardell Bridge	28 57' 16.25"S, 153 27' 56.07"E	3	Back Channel		4.5	5	4.5	**14.0**
T 10/11	Broadwater Road	28 59' 50.68"S, 153 24' 11.22"E	10	Tuckean		3	5.5	5.5	**14.0**
T12	BAG BARRAGE	28 58' 51.75"S, 153 24' 15.98"E	10	Tuckean		7.5	6.5	8.5	**22.5**
KB 13/14	Kilgin Drain to RR	29 01'31.58"S 153 22 '30.24" E	9	Kilgin/ Buckendoon		3.5	4.5	3	**11.0**
KB15	Woodburn opp town	29 4' 6.42"S, 153 20' 34.57"E	9	Kilgin/ Buckendoon		4.5	2	8	**14.5**
KB18	OAKLAND RD NEAR SCHOOL RD	29 4' 38.55"S, 153 20' 4.10"E	9	Kilgin/ Buckendoon		4.5	3	7.5	**15.0**
RC17	Rocky Mouth Creek	29 02' 40.25"S, 153 20' 09.24"E	7	Rocky Mouth Creek		6.5	6	7	**19.5**
E19	TUCKOMBIL CANAL	29 05' 05.52"S, 153 20'16.79"E	6	Evans River		4	4	6.5	**14.5**
SB20	Swan Bay	29 3' 40.89"S, 153 17' 16.87"E	8	Swan Bay		7	7	7	**21.0**

SITE		GPS	Management Zone Number	Management Zone name	BANK AND BED STABILITY	Geomorphic stability	Creek and Bank Condition	Recovery Potential	TOTAL SCORE
UPRWR21/ 22	Coraki downstream boat ramp	28 59' 6.10"S, 153 17' 14.37"E	12	Upper Richmond/ Wilsons River		5.5	5	7.5	**18.0**
UPRWR23	WYRALLA RD BRIDGE TO CORAKI	28 53' 29.78"S, 153 17' 49.75"E	12	Upper Richmond/ Wilsons River		6	5	6	**17.0**
UPRWR24	WYRALLA RD UPPER	28 52' 06.87"S, 153 16' 14.12"E	12	Upper Richmond/ Wilsons River		4	6	7	**17.0**
UPRWR25	LECESTER CR	28 47' 45.44"S, 153 14' 24.09"E	12	Upper Richmond/ Wilsons River		5.5	5	6.5	**17.0**
BU26	Bora Bungawalby n Creek	29 2' 42.08"S, 153 15' 3.72"E	11	Lower Bungawalbyn		7.5	7	8	**22.5**
BU27/28	Sandy Creek	29 1' 32.61"S, 153 15' 5.76"E	11	Lower Bungawalbyn		8.0	7	8	**23.0**
UPRWR 29/30	Tomki Tatham Bridge	28 55' 30.09'S, 153 09' 39.64"E	12	Upper Richmond/ Wilsons River		4.5	5	5.5	**15.0**
UPRWR31	Casino Weir	28 52' 4.56"S, 153 2' 33.21"E	12	Upper Richmond/ Wilsons River		5.5	5.5	4	**15.0**
UPRWR32	Wilson R Trinity	28 48' 0.09"S, 153 17' 9.39"E	12	Upper Richmond/ Wilsons River		4.5	5.0	5	**14.5**

Table 3.5 provides a summary of the issues in each zone. Some relevant photographs are provided in **Error! Reference source not found.** and Figure 3.2.

Table 3.5 Management Zone Issues.

MANAGEMENT ISSUES	MANAGEMENT ZONE											
	1-North Ck Newrybar	2 – Emigrant/	3 –Back Channel	4 –South Ballina/	5 –Rileys Hill	6 -Evans	7 –Rocky Mouth Ck	8 –Swan Bay	9 –Kilgin/ Buckendoo	10 - Tuckean	11 –Lower Bungawalb	12 –Upper Richmond/
Lack of suitable riparian vegetation (upper reaches)	X	X				X	X			X		X
Lack of suitable riparian vegetation (middle)			X				X	X	X	X		X
Lack of suitable riparian vegetation (lower reaches)			X	X	X		X				X	
Drainage modification for agriculture	X		X	X	X	X	X	X	X	X	X	X
Drainage modification with steep sided banks				X	X	X	X	X	X	X		
Drainage and bank modification for flood mitigation				X	X	X	X	X	X	X	X	
Agricultural practices removing drainage sediment	X		X	X	X	X	X	X	X	X	X	
High flow erosion susceptibility increasing bank erosion						X				X		X
Water course obstructions (constructed flow restrictions)	X	X	X	X	X		X	X	X	X	X	
Erosion from flow redirection during flood conditions						X	X					
Interruptions to natural flow regime (e.g. dam construction)		X				X				X		
Sheet and rill erosion on cleared land	X	X	X	X	X	X	X	X	X	X	X	X
Mobilisation of chemicals from horticultural activity		X										
Geological substrate with high potential for erosion			X								X	
Downstream bulk sediment movement resulting in shoaling	X	X				X						
Increasing channel width and decreasing channel depth	X					X						
Stock access to watercourses	X	X					X	X	X	X	X	X
Recreational boating and fishing access (wave erosion)	X	X	X	X	X	X	X	X	X			X
Natural meander readjustment after altered flow regime						X						
In-filling due to isolation from the river system								X				

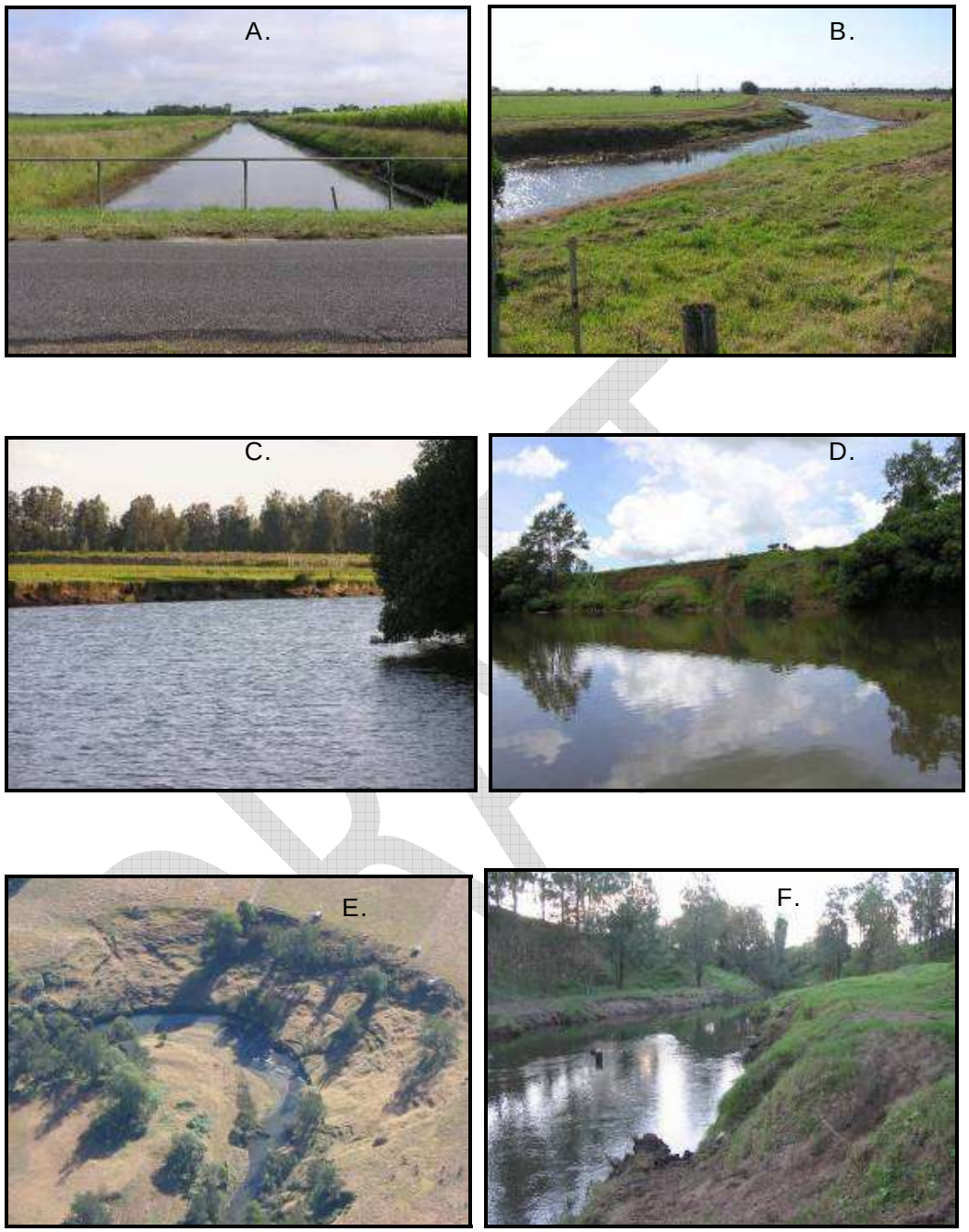

Figure 3.1. Examples of major geomorphologic issues in the Richmond River Floodplain.
A. Drainage modification for agriculture (Management Zone 9).
B. Drainage modification with steep sided banks (Management Zone 11).
C, D, E and F. Examples of bank slumping and erosion caused from removal of riparian vegetation (Management Zone 12).

Figure 3.2 Examples of major geomorphologic issues in the Richmond River Floodplain.
A. Loose rock bank protection (Management Zone 1).
B. In channel sediment build up.
C. Cattle access to watercourse.
D. Denuded section of bank and encroaching agriculture.
E. Stream section with healthy riparian vegetation.
F. River section with healthy riparian vegetation.

Note: Photographs B to F are from Management Zone 12 and taken by NSW Fisheries, but are representative of the issues for the majority of Management Zones.

Zone 1 - North Creek/Newrybar

On-ground sites NC1, NC2

Geology

The upper catchment flows east from the coastal ridge at Newrybar which is a region underlain with Tertiary Volcanics (Lismore Basalts), down onto the coastal plain which is comprised of Quaternary Sediments (river gravels, alluvium, sand and clay, as well as beach and dune sands). In the northern most portion of this catchment (Midgen Creek), the upper catchment flows from a region consisting of Neranleigh-Fernvale Metasediments. The majority of the North Creek catchment including tributaries of Birrung Creek, Newrybar drain, Deadmans Creek, Roberts Creek, and Chickiba Creek, drain through lower lying swampy areas comprised mainly of Quaternary Sediments (Brunker *et al*. 1972).

Natural Land Cover

Most of the coastal sub-catchment has been modified from its natural state for agricultural use as well as urban coastal development on some upland ridgelines. The management zone has been extensively drained and cleared with a network of connecting artificial drainage systems adjacent to the coastal heath which has been selectively retained along the beach dune systems.

Current Land Use

The North Creek/Newrybar management zone has been cleared for grazing (cattle) and horticultural purposes in the upper reaches, and drained for agricultural purposes (predominantly sugar cane), on the lower lying areas. Dredging and expanding urban development is occurring in this area.

Soils

The North Creek/Newrybar management zone is made up of alluvial, red basaltic (kraznozem), podzol soil types, and coastal heath sands (Donnelly 1997).

Stream Pattern

The stream pattern can be described as dendritic in the upper region and both centripetal (unaltered) and distributary (altered with drainage) in the middle and lower reaches (Grotzinger *et al*. 2007).

Bank Stability

The upper reaches are lacking in riparian vegetation due to clearing for grazing which has lead to bank erosion and transportation of sediment downstream. The coastal sand plain is characterised by extensive drainage channels in which siltation (transported from upstream) is actively removed and often dumped as spoil along the banks as part of management practices to keep drains open. Riparian vegetation is non-existent along drainage channels due to the need for efficient drainage and access, as well as the practice of maximising land

area for crop production. The middle section of North Creek passes through Ballina Nature Reserve and as such has extensive riparian vegetation resulting in good bank stability and erosion control. The lower estuary area has some loose rock protection, adjacent to urban settlement, where meander channels are undercutting the shoreline (WBM 2006).

Sediment Transport/Movement

The opportunity for sediment transport and movement is evident in the upper boundaries of the management zone due to past land clearing practices and a lack of riparian vegetation. The sediment is transported downstream in "slugs" during times of high rainfall making its way into the lower estuary (Hossain *et al*. 2001). Here, the sediment is trapped and is accreting in expanding mangrove forests. From the ocean side, marine sands are developing shoals around the Missingham Bridge area.

Zone Specific Issues

Major issues for the North Creek/Newrybar management zone include a lack of suitable riparian vegetation in the upper reaches which provides increased opportunity for bank instability and sediment mobilisation. Current agricultural practices for sugar cane farming provide a source of unconsolidated sediment as drain clearance spoil is readily transported downstream in high rainfall events.

- Lack of suitable riparian vegetation in upper reaches leading to bank instability.
- Drainage modification for agriculture.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Stock access to upper catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Recreational boating and fishing access in lower catchment.
- Sheet and rill erosion on cleared land.
- Catchment and marine sediment movement resulting in estuary shoaling.
- Increasing channel width and decreasing channel depth in the lower catchment.

Zone 2 - Emigrant/Maguires Creek

On-ground sites EC3

Geology

Maguires Creek drains the eastern portion of the Alstonville plateau which is a region of Tertiary volcanic rock named Lismore Basalt. Off the edge of the plateau, the creek passes through exposed sections of ancient Palaeozoic strata identified as Neranleigh-Fernvale Metasediments, then flows down onto the coastal plain which is comprised of Quaternary Sediments (river gravels, alluvium, sand and clay). Tributaries of Maguires Creek include Willowbank Creek, Branch Creek and Houghlahans Creek. Maguires Creek joins Emigrant Creek 2km north west of West Ballina. Emigrant creek begins just east of Newrybar and cuts through Lismore Basalts, some minor outcrops of Neranleigh-Fernvale Metasediment at Tintenbar, before flowing onto the coastal plain at Cumbulum. Tributaries of Emigrant Creek include Sandy Flat Creek, (Brunker *et al*. 1972).

Natural Land Cover

Basalt areas were originally covered in rainforest which was known as the Big Scrub. Most of the management zone has been modified from its natural state for agricultural use as well as urban development on upland areas (eg. Alstonville). The management zone has been extensively cleared, originally for dairying, but in more recent times much of the upland area has been converted to horticulture which is mainly Macadamia Nut production. Natural vegetation cover has been removed with only the occasional isolated pocket of remnant vegetation remaining as an example of the once broad and rich species mix.

Current Land Use

The management zone has been extensively cleared for grazing (cattle) and horticultural purposes (WBM, 2006). Some areas are no longer used for agricultural production and are regenerating original forest vegetation cover, but with an increased mix of exotic weed species.

Soils

The management zone is made up of alluvial, red basaltic (kraznozem) and podzol soil types (Donnelly, 1997).

Stream Pattern

The stream pattern of Maguires Creek can be described as radial from the Alstonville plateau and parallel in the areas of pronounced localised relief. The stream pattern of Emigrant Creek can be described as parallel in the upland areas and both catchments are centripetal in the middle and lower reaches (Grotzinger *et al*. 2007). Emigrant Creek Dam is located in the middle to upper reaches of Emigrant Creek, at Knockrow, and was commissioned in late 1953. It should be noted that since construction there have been significant effects

downstream in relation to altered flow regimes and sediment movement. In more recent times, significant effort has been put into catchment revegetation around the Emigrant Creek Dam. Marine dominated shoaling occurs at the confluence with Richmond River.

Bank Stability

The upper reaches of the management zone are lacking in riparian vegetation due to clearing for grazing which has in turn lead to extensive erosion of banks and transportation of sediment downstream (WBM 2006). With a more recent change from grazing to horticulture some landholders have replanted riparian corridors resulting in bank stabilisation and improved stream management. Areas that are not currently used for agricultural production tend to have naturally regenerating riparian zones, however, the species mix is often predominantly exotic (i.e. Camphor Laurel). The coastal sand plain is characterised by extensive existing riparian corridors dominated by Mangrove species.

Sediment Transport/Movement

The past land clearance for grazing would have contributed significantly to the sediment load. With the change in land use to predominantly horticultural activity exposed soils and landforms will depend on crop style and farm management practices. Sediment contributions to the system also occur during the establishment of the chosen crop. The opportunity for sediment transport and movement is most evident in the steeper upper boundaries of the management zone with a lack of riparian vegetation. The sediment is transported from higher elevations downstream in “slugs” during times of high rainfall and accumulates in the lower energy drainage network of the coastal floodplain. This is evidenced by expanding mangrove forests and extensive shoaling in estuarine and tidal channels (WBM 2006).

Zone Specific Issues

A major issue for the Emigrant/Maguires Creek management zone is a lack of riparian vegetation in the steeper upper areas of the drainage network where higher stream velocities readily erode banks leading to increased sediment transport and deposition lower down in the catchment.

- Lack of suitable riparian vegetation in upper reaches leading to bank instability.
- Interruption of natural flow regime with construction of Emigrant Creek Dam.
- Sheet and rill erosion on cleared land.
- Potential mobilisation of chemicals due to horticultural management practices.
- Stock access to upper catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Recreational boating and fishing access in lower catchment.
- Bulk sediment movement resulting in downstream estuary shoaling.

Zone 3 -Back Channel

On ground sites BC8

Geology

The Back Channel management zone drains the eastern portion of the Blackwall Range which is a complex geological feature comprised of predominantly Mesozoic sediment (sandstone, siltstone, claystone and conglomerate) which is named the Tabulum Group. There are some minor Lismore Basalt caps above these sedimentary layers at higher elevations and significant outcrops of Neranleigh-Fernvale Metasediments below, adjacent to the coastal plain. The coastal plain is comprised of Quaternary Sediments including river gravels, alluvium, sand and clay (Brunker *et al*. 1972). The area is drained by a number of minor water courses such as Bingal Creek and areas under agriculture are networked with a constructed drainage system.

Natural Land Cover

Basalt areas were originally covered in rainforest which have now been cleared for agriculture. Steeper slopes in the management zone remain forested with a strip of farmed land at the base of the Blackwell Range down onto the coastal plain. The centre portion of the coastal plain remains as Crown Reserve, and is predominantly low-lying swampland and scrub. The proposed route for the Pacific Highway upgrade runs through the farmed land between the Blackwell Range and Crown Reserve.

Current Land Use

The management zone has been partially cleared on lower slopes and sections of the coastal plain for cropping (sugar cane), especially those areas adjoining the Richmond River. Higher slopes are utilised for cattle grazing and minor horticultural activities. To the north west of Wardell a significant area (~1km^2) is being mined for mineral sands.

Soils

The management zone is made up of red basaltic (kraznozem), podzol and alluvial soil types (Donnelly 1997).

Stream Pattern

The natural stream pattern can be described as centripetal which connects with a series of modified distributary channels within agricultural cropping areas. Many of the modified watercourse channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

The eastern range escarpment is incised with a series of steep flowing and eroded water courses which connect to Bingal Creek. The upper reaches have retained riparian vegetation which diminishes significantly in the lower reaches and in areas under agricultural production on the coastal plain. Drainage networks with the extensive Crown Reserve retain natural vegetation cover. Bank stability along this section of the Richmond River is artificially

maintained with a series of loose rock walls, especially around the town of Wardell (WBM 2006).

Sediment Transport/Movement

As the Blackwall Range is primarily sedimentary strata it is more susceptible to erosion, and as such, higher sediment loads should be anticipated from this area as a natural process. Consequently, it is particularly important to retain riparian vegetation on the upper steep slopes which will help minimise and manage the erosion of unconsolidated sediment.

Zone Specific Issues

A major issue for the Back Channel management zone is in the upper reaches where steep gullies leading to the Blackwall Range pass through geological substrate that has a high potential for erosion. It is especially important to maintain vegetation cover in this area.

- Lack of riparian vegetation in agricultural areas of both the lower and middle reaches leading to bank instability.
- Drainage modification to facilitate improved agricultural production.
- Agricultural practices remove drainage vegetation and sediment which is deposited along the bank.
- Sedimentary substrate of the upper reaches is particularly vulnerable to erosion on cleared land.
- Recreational boating and fishing access on the Richmond River.
- Sheet and rill erosion on cleared land.
- Stock access to upper and mid catchment watercourses.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Uncertainty associated with erosion implications of the Pacific Highway upgrade and flooding.

Zone 4 -South Ballina/Empire Vale

On ground sites SB4, SB5, SB6, SB7

Geology

The South Ballina/Empire Vale management zone is drained by minor tributaries, Mosquito Creek, Empire Vale Creek, Reedy Creek, Boundary Creek and Everson's Creek, all of which have been extensively modified for use as drainage channels for agriculture. Most of the management zone is comprised of Quaternary Sediments of which the eastern portion is predominantly beach and dune sands and the western portion is comprised of river alluvium.

East of Broadwater is Cook's Hill which is the only elevated portion in the zone and is comprised of ancient Palaeozoic metamorphic rock types, group named as Neranleigh-Fernvale Metasediment (Brunker *et al*. 1972).

Natural Land Cover

The management zone was originally covered with low lying swampland, coastal heath, and portions of littoral rainforest in the lee of the beach hind dunes. Richmond River Nature Reserve is in the lower estuarine area of this zone.

Current Land Use

The area has been extensively sand mined along the coastal dune systems and cleared between back dunes and the river for agriculture (sugar cane). A small southern section east of Broadwater is not under agriculture and is predominantly heath land.

Soils

The management zone is made up of mainly alluvial and coastal heath soil types (Donnelly 1997) with a small section of podzolic soil east of Broadwater.

Stream Pattern

The natural stream pattern is now essentially only modified distributary channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

Most of the drainage network for the management zone is maintained by farm management practices which require free flowing movement of groundwater away from areas of crop production. Banks are inherently unstable due to the use of machinery for their modification and construction and this results in unnatural steep sides as a means to maximise cropping area and agricultural production. Feasibility studies are currently being conducted through NSW NPWS in order to manage erosion issues at Mobbs Bay. The erosion at Mobbs Bay has been exasperated by a slumping in the sub-tidal barrier over the last 15 years.

Sediment Transport/Movement

High rainfall events will result in significant sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation (WBM 2006). This can lead to the easy movement of unconsolidated sandy sediment and loam soil types during periods of high flow rates.

Zone Specific Issues

As the zone is relatively flat and wholly contained within the Lower Richmond River Floodplain management issues are primarily concerned with drainage and flood mitigation.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.

- Drainage modification with steep sided unnatural banks.
- Recreational boating and fishing access on the Richmond River.
- Drainage modification for flood mitigation (including levee construction and flood gates).
- Sheet and rill erosion on cleared (agricultural) land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.
- Drainage modification to facilitate improved agricultural production.
- Mobbs Bay shore erosion issues.

Zone 5 -Rileys Hill

Geology

Rileys Hill management zone is drained by unnamed minor tributaries, some of which drain the northern portion of Broadwater National Park. Most of the management zone is comprised of Quaternary Sediments (alluvium, sands and clay) but Rileys Hill, which is the only elevated portion of the management zone, is an outcrop of Mesozoic sediment (Tabulam Group, including sandstone, shale and conglomerate) (Hanlon *et al*. 1970).

Natural Land Cover

The management zone was originally covered with low lying swampland, adjacent to the river, heath on the sand plain, and a portion of woodland on the elevated ridge of Rileys Hill.

Current Land Use

The area has been extensively cleared along the river floodplain for agriculture (sugar cane) and residential development on Rileys Hill. A significant portion of the management zone is part of Broadwater National Park.

Soils

The zone is made up of mainly alluvial and coastal heath soil types (Donnelly 1997) with a small section of podzolic soil at Rileys Hill.

Stream Pattern

The natural stream pattern is now essentially only modified distributary channels within agricultural areas and most channels connect directly to the Richmond River (Grotzinger *et al*. 2007).

Bank Stability

Other than drainage originating in Broadwater National Park most of the drainage network for the management zone is maintained by farm management practices which require free flowing movement of groundwater away from areas of crop production. Banks are inherently

unstable due to a lack of vegetation and the use of machinery for their construction and modification. This results in unnatural steep sides as a means to maximise cropping area and agricultural production. The main Richmond River bank retains a fringe of mangroves for most of the management zone.

Sediment Transport/Movement

High rainfall events will result in sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation and constructed in loamy soils with unconsolidated sediment. Significant sections of the floodplain zone are impacted by major flood events in the Richmond River (WBM 2006).

Zone Specific Issues

Issues associated with a reliance on a modified and constructed drainage network, in association with measures for flood mitigation, are the primary concerns within the management zone.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Drainage modification to facilitate improved agricultural production.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Recreational boating and fishing access on the Richmond River.
- Drainage modification for flood mitigation (including levee construction and flood gates).
- Sheet and rill erosion on cleared (agricultural) land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on farmed agricultural land.

Zone 6 - Evans

On ground sites E19

Geology

The Evans management zone is not contained by catchment boundaries and geologically is situated primarily on Quaternary Sediments (i.e. alluvium, sands and clay), although the Evans River passes through outcrops of Mesozoic Sediments, including the Tabulam Group and the Redcliff Coal Measures, at a river constriction known as Iron Gates. The Evans headland is a complex geological area that includes Palaeozoic Metasediments. Quaternary beach sands and dune complexes extend north from the river mouth (Hanlon *et al*. 1970).

Natural Land Cover

The majority of the management zone is part of either Broadwater National Park (north) or Bunjalung National Park (south) and typifies the original heath land and swamp vegetation of the area. Coastal woodland can be found on low ridgelines of Mesozoic sediment that traverse sections of the Parks.

Current Land Use

The western portion of the management zone (adjacent to Woodburn) has been cleared along the river floodplain for agriculture, mainly sugar cane and some cattle grazing. The township of Evans Head extends across the floodplain and headland at the mouth of the Evans River.

Soils

The management zone is made up of predominantly alluvial soil types closer to the Rivers and sandy coastal heath in the rest of the area (Donnelly 1997).

Stream Pattern

Sawpit Creek, Brady arm Creek, Oyster Creek and Rocky Mouth Creek drain the elevated ridgelines of Mesozoic Sediments south of the Evans River with a centripetal stream pattern. The Tuckombil Canal was constructed around 1900 and connects Rocky Mouth Creek, a tributary of the Richmond River, with the upper reaches of the Evans River. This has major implications for bank stability and movement of sediment, especially during times of flood and/or high flow regimes. The purpose of the Tuckombil Canal construction was to alleviate flooding in the mid Richmond area. The section of Rocky Mouth Creek (from Tuckombil Canal to the Richmond River) can be subject to flow reversal dependant upon flow regimes and river levels. Control of water through the canal is by means of a temporary concrete fixed weir, replacing the fabridam about seven years ago (B. Eggins, pers.comm. 2009).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has virtually no (or extremely ineffective) riparian vegetation for most of the management zone. The increased flow regime during times of flood has had a detrimental effect on much of the bank stability for the Evans River. Some banks appear to have receeded many tens of metres since 1953 (WBM 2002). Property owners are encouraged to fence off river banks from stock access, with grant funding being provided through local government.

Sediment Transport/Movement

Floodwaters originating from the upper Richmond catchment are redirected through the Tuckombil Canal resulting in significant detrimental impacts on the Evans River System. Therefore, upstream high rainfall events will result in additional sediment mobilisation from beyond the natural catchment and with a lack of natural riparian vegetation along the canal and upper reaches compound the usual erosion and deposition issues. Sections of the Evans

River floodplain will be impacted by "overflow" flood events from the Richmond River (WBM 2002).

Zone Specific Issues

The major issue for the Evans management zone is alteration of natural flow regimes following construction of the Tuckombil Canal and the impact of higher flows increasing bank erosion along the length of the main river channel.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Recreational boating and fishing access on the Evans River and Richmond River.
- Bank erosion is mainly the result of the higher energy associated with flooding from the Richmond River through Tuckombil Canal.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes.
- The increase in flows is causing bank erosion and the downstream bulk transport and deposition of channel sands in the Evans River, upstream of Iron Gates.
- The sediment derived from bank erosion is gradually transported downstream mainly by flood flows and is causing significant shoaling between Iron Gates and Elm Street bridge. A sedimentation study in 1986 shows the material in the Evans is marine derived and it is natural shoaling. The Tuckombil canal and Evans were eroding at the same pace as other streams and rivers.
- Natural meander readjustment of the Evans River channel is working to increase depth as a result of altered flow regimes.
- Erosion from flow reversal and redirection of floodwater in lower Rocky Mouth Creek during peak flood conditions. There is some scouring just downstream of the tidal structure (GHD 2006).
- Sheet and rill erosion on cleared land along lower Rocky Mouth Creek and around Woodburn.
- Control and alteration of flow regimes by means of a Fabridam at the head of Tuckombil Canal.

Zone 7 -Rocky Mouth Creek

On ground sites RC17

Geology

Rocky Mouth Creek management zone is situated primarily on Quaternary Sediments (i.e. alluvium, sands and clay), with the upper catchment around the Mooninba Range comprised of Mesozoic Sediments including the Tabulam Group and the Walloon Coal Measures (Hanlon *et al*. 1970).

Natural Land Cover

Most of the management zone has been cleared of its original vegetation which was originally low lying swamp and wetland forests with open woodland on elevated ridges.

Current Land Use

The river floodplain is used for agriculture, mainly sugar cane and some cattle grazing, and is recognised as a hot spot for acid sulphate soils (Ferguson and Eyre 1995).

Soils

The management zone is made up of predominantly alluvial soil types with podzolic soils on elevated slopes and ridges (Donnelly 1997).

Stream Pattern

The stream pattern of the tributaries of Rocky Mouth Creek can be described as largely modified distributary drainage channels. Former dendritic water courses such as Swampy Creek are no longer connected to the natural drainage network and have been modified through agricultural land use. The lower reaches of Rocky Mouth Creek between the Richmond River at Woodburn and the Tuckombil Canal can be bi-directional, controlled by a "Fabridam" (inflatable rubber barricade) that prevents the intermixing of Evans River and Rocky Mouth Creek waters, except during flood events (Grotzinger *et al*. 2007).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has virtually no (or extremely ineffective) riparian vegetation for most of the zone. Rocky Mouth Creek has sections of riparian vegetation but the majority of the creek banks are unstable, having been cleared to allow for cattle access and maximisation of land for cropping.

Sediment Transport/Movement

The flow characteristics of Rocky Mouth Creek are influenced by the flow in the Tuckombil Canal. In times of flood, water will back up in Rocky Mouth Creek and as the majority of sediment transport occurs during flood events it can be expected that some sediment movement will be diverted into the Evans River system via Tuckombil Canal as drained flood overflow (WBM 2002).

Zone Specific Issues

Extensive drainage for agriculture across the zone and alteration of flow regimes through the connection of lower Rocky Mouth Creek with the Tuckombil Canal are the major management issues.

- Lack of natural riparian vegetation across upper, middle and lower reaches in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Bank erosion resulting from higher energy associated with flood redirection from the Richmond River through Tuckombil Canal.
- Some banks have been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes along the Richmond River.
- Stock access to watercourses on grazing properties.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.

Zone 8 -Swan Bay

On ground sites SB20

Geology

Swan Bay management zone includes a major anabranch of the Richmond River and is connected via a small channel to the main river. The zone is comprised entirely of Quaternary Sediments (i.e. river alluvium) (Hanlon *et al*. 1970).

Natural Land Cover

The management zone was originally covered with mid floodplain mixed vegetation, dominated by low lying wetland species.

Current Land Use

The area has been almost entirely cleared for agriculture, principally sugar cane and cattle grazing.

Soils

The management zone is solely river sourced alluvial soil types (Donnelly 1997).

Stream Pattern

All water courses flowing into the anabranch are modified distributary drainage channels. The anabranch is slowly infilling with sediment as it becomes further disconnected from the river system with only low energy water movement. Flood sourced sediment is transported across and into the management zone during major flood events (Grotzinger *et al*. 2007).

Bank Stability

The drainage network for the management zone is maintained by farm management practices. The main Richmond River bank retains a very thin (and mostly ineffective) fringe of riparian vegetation for much of the zone. Consequently, the river bank is unstable and erodes during flood events (WBM 2006).

Sediment Transport/Movement

High rainfall results in significant sediment mobilisation due to most drainage channels being devoid of natural riparian vegetation and this can lead to easy movement of the unconsolidated alluvial soil. Most sections of the floodplain within the zone will be impacted by overflow floodwaters from the Richmond River.

Zone Specific Issues

Major issues include drainage modification for agriculture and flood mitigation and sediment infill of the Swan Bay anabranch.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Infilling due to isolation from river system.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.
- Stock access to watercourses.

Zone 9 -Kilgin/Buckendoon/Dungarubba

On ground sites KB14, KB15, KB18

Geology

The management zone is almost exclusively Quaternary Sediments (i.e. river alluvium), with the exception of Newbys Hill and McPherson Trig Station at Bungawalbyn. These are two small elevated outcrops of Mesozoic Sediments which are further identified as Walloon Coal Measures and Kangaroo Creek Sandstone rock substrate (Hanlon *et al*., 1970; Brunker *et al*. 1972).

Natural Land Cover

Virtually all the management zone has been drained and cleared of its original vegetation which was originally low lying wetland forests and floodplain woodlands. Only small fragments of original vegetation remain as slightly elevated isolated remnants.

Current Land Use

The river floodplain is exclusively used for agriculture, mainly sugar cane and some cattle grazing on elevated areas.

Soils

The management zone is made up of mainly alluvial soil types (Donnelly 1997), except for the two elevated knolls at Bungawalbyn which have a podzolic soil profile.

Stream Pattern

The stream pattern within the zone can be described as mainly modified distributary drainage channels. Former dendritic water courses, such as Dungarubba Creek, have been altered and now exist as part of the agricultural drainage network (Grotzinger *et al*. 2007).

Bank Stability

The drainage network throughout cleared areas of the management zone is maintained by farm management practices. The main Richmond River bank has minimal riparian vegetation in some areas and is subject to erosion (WBM 2006). The majority of the drainage banks have been cleared to allow maximum utilisation of land for cropping and grazing, and consequently can be regarded as unstable at times of high flow.

Sediment Transport/Movement

Sediment transport and movement is greatly influenced by the extent of fallow agricultural land at the time of higher rainfall events. The extensive drainage network facilitates the ready transport of sediment away from ploughed paddocks and often directly into the river system. During flooding sediment is easily moved and distributed across the floodplain area in accordance with currents and the extent of inundation (WBM 2006).

Zone Specific Issues

The major issue for the Kilgin/Buckendoon management zone is a lack of natural riparian vegetation and farm management practices which maintain most watercourses as open drains.

- Lack of natural riparian vegetation in agricultural areas resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove vegetation and sediment from drains which is often deposited along the bank.
- Recreational boating and fishing access on the Richmond River.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes along the Richmond River.
- Stock access to watercourses on grazing properties.
- Sheet and rill erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.

Zone 10 -Tuckean

On ground sites T11, T12

Geology

Tuckean management zone is almost exclusively Quaternary Sediments (i.e. alluvium, river gravels, sand and clay), but is fringed with lower elevated outcrops of Mesozoic Sediments including the Tabulum Group, Walloon Coal Measures and Kangaroo Creek Sandstone. These layered sediments are found in low ridges to the east, north and west of the drainage floodplain and higher elevations in these areas are capped with Tertiary Basalts (Hanlon *et al*. 1970; Brunker *et al*. 1972).

Natural Land Cover

Most of the management zone has been extensively drained and cleared of its original floodplain and swampland vegetation to provide for agricultural production. However, the lower lying centre of the zone has retained some natural and regenerating vegetation within the Tuckean Nature Reserve. Much of the Reserve is a mix of floodplain and swampland vegetation bisected by major drainage channels.

Current Land Use

The Tuckean has a mix of cropping (sugar cane), mainly around the southern and western margins, with cattle grazing being predominant to the north and alongside the Nature Reserve in the west and east.

Soils

The management zone is made up of mainly alluvial soil types (Donnelly 1997), with podzolic soils on elevated portions to the west at Tuckurimba, north at Cedar Island, and east along the Blackwall Range.

Stream Pattern

The stream pattern of watercourses can be described as modified distributary drainage channels throughout the bulk of the floodplain area that connects through to Bagotville at the head of the Tuckean Broadwater. A barrage at Bagotville restricts tidal movement and ingress of saltwater beyond the Broadwater. A centripetal network of streams originally drained the Tuckean Basin, however, natural drainage patterns are now only evident in the upper reaches of Stibbards Creek, Tucki Tucki Creek, Marom Creek, Youngman Creek, Gum Creek, and Yellow Creek, all of which are now connected to major drainage channels (Grotzinger *et al*. 2007). The Tuckean is regarded as a hotspot for Acid Sulphate Soils as a consequence of lowering water tables via extensive drainage modification (Ferguson and Eyre 1995).

Bank Stability

The drainage network in the cleared areas of the management zone is maintained by farm management practices. Major drainage channels within Tuckean Nature Reserve retain clearance spoil on the banks and consequently are not naturally vegetated. Drainage channels are generally steep sided, poorly stabilised and subject to erosion during periods of high flow. The majority of the drainage banks have been cleared to allow maximum utilisation of land for cropping, stock access, and ease of maintenance. Bank stability along the Tuckean Broadwater is poor due to flow constrictions at the Bagotville Barrage which channel water and provide higher energy for increased erosion downstream. Much of the land area is subject to flooding.

Sediment Transport/Movement

In high rainfall events the drainage network facilitates the ready transport of sediment away from ploughed paddocks and grazing areas to be deposited along the major channels of the Tuckean Basin. This requires regular clearance and maintenance, especially as waters slow toward the Barrage in all but the greater flood events. During flooding beyond the drainage channels sediment is easily moved and distributed across the basin area in accordance with currents and the extent of inundation (WBM 2006).

Zone Specific Issues

Management of the Tuckean is an ongoing problem centred on the positive and negative consequences of the Bagotville Barrage. Primarily, siltation is an issue within the agricultural drainage network and erosion is a concern downstream of the barrage.

- Lack of natural riparian vegetation in agricultural areas of the middle and upper reaches, resulting in bank instability.
- Drainage modification with steep sided unnatural banks.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes, upstream of the Bagotville Barrage.
- Drainage modification to improve opportunities for agriculture.
- Increased bank erosion as a result of high flow channelling through the Bagotville Barrage.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Interruption to the natural flow regime with the construction of the Baggotville Barrage.
- Sheet and rill erosion on cleared land.
- Stock access to watercourses on grazing properties.
- Agricultural encroachment on wetland vegetation.
- ASS hot spot.

Zone 11 -Lower Bungawalbyn

On ground sites BU28

Geology

The Swan Bay/Lower Bungawalbyn management zone is a mix of Quaternary Sediments (i.e. river alluvium, gravels, sand and clay) on the lower floodplain, and Mesozoic Sediments (Kangaroo Creek and Grafton Formation Sandstones) on higher elevations and upper tributary catchments. Some small Tertiary Basalt caps are present in the Ellangowan district and the management zone is separated from the Coastal sub-catchment in the south east by the Richmond Range, an extensive and elevated area of Grafton Formation Sandstone (Hanlon *et al*. 1970; Brunker *et al*. 1972).

Natural Land Cover

Much of the management zone has retained its original vegetation in an extensive network of State Forests. Although the forests have been managed and supplemented with selected

plantation eucalypt species they can still be regarded as a retention of a more representative natural vegetation cover (for the particular soil types and geological substrate) than any other management zone of the Richmond Floodplain. However, lower reaches of the zone, around Bungawalbyn and Bora Ridge, have been cleared for agriculture. Original vegetation of these areas would have included a higher swampland and floodplain species mix.

Current Land Use

The river floodplain in lower reaches and along the major watercourses has some agricultural use with cropping and cattle grazing. However, the majority of the management zone is NSW State Forest, including Bungawalbyn, Ellangowan, Myrtle, Whiporie, Giberagee, and Doubleduke State Forests. Some large sections of these forests are maintained and managed as plantations.

Soils

The management zone is made up of primarily alluvial soil types (Donnelly 1997), and podzolic soils on the elevated Sedimentary substrates.

Stream Pattern

The drainage pattern of streams are centripetal and remain largely natural except for drainage modification to suit agricultural practice in the lower reaches, close to the Richmond River around Bungawalbyn and Bora Ridge. Major connecting streams of Bungawalbyn Creek include Sandy Creek to the north, Myrtle Creek to the south west, with Myall Creek and Scrubby Creek to the south (Grotzinger *et al*. 2007). Each of these tributaries drain large areas of State Forest. Much of the land area is subject to flooding.

Bank Stability

The drainage network within agricultural cropping areas of the Lower Bungawalbyn Creek is maintained by farm management practices. Due to a catchment of lower gradient landforms bank heights are more moderate than the other Richmond River sub-catchments and consequently banks are generally more stable, however, bank instability is still present. This is especially so with the areas of State Forest where extensive natural and riparian vegetation is maintained.

Sediment Transport/Movement

The Lower Bungawalbyn management zone is an area of the greater Bungawalbyn Creek sub-catchment of the Richmond River Basin where sediment transport and movement is substantially less due to flatter topography and extensive vegetation cover within State Forest estate (Hossain *et.al.* 2002). Podzolic soils and sandy alluvium are less susceptible to transport in high rainfall events when stream gradients are low and natural vegetation maintains bank stability.

Zone Specific Issues

Recognition of a geological substrate with a high potential for erosion is a major issue for the Lower Bungawalbyn management zone. Despite gentler slopes and lower landforms in upper and mid reaches it is particularly important to maintain suitable riparian zones along watercourses which will minimise erosion potential. The low lying nature of the zone results in substantial flooding.

- Lack of natural riparian vegetation in agricultural areas (particularly the lower reaches) resulting in bank instability.
- Agricultural practices remove drainage vegetation and sediment which is often deposited along the bank.
- Some banks have also been weakened by the removal of riparian vegetation, mainly for flood mitigation purposes on lower reaches adjacent to the Richmond River.
- Some exposed and sandy unconsolidated soils with high potential for erosion in areas of cleared landscape, generally agricultural areas.
- Stock access to watercourses on grazing properties.
- Sheet, rill, and gully erosion on cleared land.
- Unsuitable drainage and watercourse obstructions (bridges, crossings, pipes) which cause flow restrictions on agricultural land.
- Drainage modification to improve opportunities for agriculture.
- ASS
- Blackwater source after flooding events.

Zone 12 - Upper Richmond/Wilson Management Zone

On ground sites UPRWR21/22, UPRWR23, UPRWR24, UPRWR25, UPRWR26, UPRWR30, UPRWR32, UPRWR32

Geology

The Upper Richmond/Wilson management zone is a mix of Quaternary Sediments (i.e. river alluvium, gravels, sand and clay) on the lower floodplain, and Tertiary Basalts on higher elevations and fringing ridgelines (Brunker *et al*. 1972).

Natural Land Cover

Most of the management zone has been cleared of its original vegetation which was primarily low lying wetland forests and woodlands on the floodplain, grading through to dense areas of rainforest on the basalt soils and southerly aspects of higher elevations. Only small fragments of original vegetation remain, usually as isolated and unconnected remnants in

elevated areas. Some significant areas such as Tucki Tucki Nature Reserve, are retained on northerly and western aspects of some floodplain bordering ridgelines.

Current Land Use

The river floodplain has a dual agricultural use with cropping (mainly sugar cane) on the lower reaches of the Wilson's River and Pelican Creek sub-catchment at North Codrington, and cattle grazing in upper reaches on both the floodplain and surrounding slopes. The floodplain of the Richmond River between Coraki and Tatham also has dual agricultural use with a mix of both cropping and cattle grazing.

Soils

The management zone is made up of primarily alluvial soil types (Donnelly 1997), and basalt derived kraznozem and chocolate soils on elevated and surrounding slopes.

Stream Pattern

Except for the lower reaches around North Codrington and South Gundurimba there is minimal drainage alteration to facilitate agricultural cropping. The stream pattern of the minor tributaries that flow into the Wilson's River below Lismore, plus Pelican Creek, can be described as centripetal. Some minor streams south of Lismore are maintained as drains within grazing properties and also as a drainage network in areas adjacent to urban and industrial development. A farm drainage network is also maintained along both banks of the Richmond to Tatham. Only one named tributary, Walsh's Creek (also centripetal in stream pattern), enters the main river channel at Codrington (Grotzinger *et al*. 2007).

Bank Stability

The drainage network within agricultural cropping areas of the Lower Richmond and Wilson's Rivers is maintained by farm management practices. The main Wilson's River bank has minimal riparian vegetation in most areas and the connecting minor streams are generally totally cleared and stabilised by grazing pasture only. Pelican Creek retains some form of riparian vegetation for approximately half its length but has exposed banks through areas of agricultural cropping. The Richmond River has typically high steep banks and minimal riparian vegetation. Significant sections of the bank are devoid of any vegetation as a result of clearing for cattle access and erosion during past flood events (WBM 2006).

Sediment Transport/Movement

The Upper Richmond/Wilson management zone is an area of mid-catchment for the Richmond River Basin where sediment transport and movement is influenced by the extent of fallow agricultural land at the time of higher rainfall events. During floods and as a consequence of elevated landforms in the upper regions of both the Wilson's River and Richmond River sub-catchments suspended sediment loads have been estimated at greater than 93% compared to the Bungawalbyn Creek sub-catchment which has flatter topography and extensive forest coverage (Hossain *et.al.* 2002). The drainage network facilitates the ready transport of sediment away from both ploughed and grazing paddocks and into the

river system. With the higher energy of flooding sediment is easily moved and distributed across the floodplain area in accordance with currents and the extent of inundation.

Zone Specific Issues

Cattle access to steep sided drainage channels and the main riverbank create a management concern as regularly used tracks remain unvegetated and are further eroded in times of flood. Most of the typically steep banks of the zone are cleared of riparian vegetation and are vulnerable to erosion during high flow flood events.

- Lack of natural riparian vegetation in agricultural areas of upper and middle reaches resulting in bank instability.
- Recreational boating and fishing access on the Richmond and Wilsons River.
- Sections of unstable and unvegetated banks as a result of stock access to watercourses.
- High steep banks susceptible to ongoing erosion during high flow conditions.
- Sheet, rill, and gully erosion on cleared land.
- Drainage modification to improve opportunities for agriculture.

4 Water Quality Impacts

4.1 Summary

The E2 modelling results provide very useful information that helps inform the management needs for each management zone.

Additionally, Table 4.1 in the CZMS describes the in-stream and downstream contributions of loading from each of the management zones under three different flow conditions.

The assessment approach was an informed semi-quantitative method of enabling a snapshot understanding of management issues associated with water quality impacts. Current information as well as previous data analyses and interpretation (ABER 2008) are used to inform the following discussion of each management zone.

Also a photographic archive of management zones is presented in Appendix 2.

4.2 Background

The Richmond River is predisposed to water quality challenges due to its relatively small catchment area (6979km^2) and large floodplain (990km^2) with a very small water surface area (19km^2). It is a poorly flushed system with a tidal pinch near Pimilco which results in poor water exchange upstream from this area. The upper catchment areas have largely been cleared and the land use is now predominantly agriculture. This change in land use has contributed to high TSS and nutrient loadings from these areas. Additionally, there are eight sewage treatment plants in the study area and several more in the catchment area, which manage waste from the larger urban areas including Ballina, Lismore, Casino, Wardell, Alstonville, Nimbin, Dunoon, and Coraki. Stormwater runoff from these urban areas also enters the Richmond River. The large expanse of rural residential living within the area also results in a significant number of on-site sewage treatment facilities. The labyrinth of road networks and the lack of hard surfaces on some of these also contributes to TSS loading.

The hydrology of the large floodplain has largely been modified through drainage channels and changes in vegetation types. The exposure of Acid Sulfate Soils (ASS) has occurred as a result of floodplain drainage and other activities that altered the ground water hydrology. Flood waters can become acid when draining occurrs from large areas of ASS. Blackwater events are significant post flooding in the Richmond River Estuary and Eyre et al. (2006) have determined that at 25˚ the Richmond River floodplain has the potential to deoxygenate 12.5 x 10^3 mL of saturated freshwater. This scale of deoxygenation is sufficient to completely deoxygenate floodwater stored on the flood plain within 3 to 4 days. Historical information

suggests that flood water can persist on the floodplain for around 6 days and in some places for several weeks. Both black water events and acid water event have contributed to fish kills in the Richmond River. There are also potential health risks related to mosquito borne infections after flood events and while water is still stored on the floodplain. Healthy, ecologically balanced wetlands systems can minimise mosquito infestation.

It will be important for the Management Plan to provide actions that build resistance in the Richmond River so the extreme effects flood events do not result in a collapse of the environmental services the river provides. Future climate change scenarios in this region predict more frequent and intense storm activity which will potentially result in more storm surge, erosion and flood events. Richmond River must be able to recover between events to ensure its long term health. Currently, it is not known when a critical threshold will be reached in the Richmond River where recovery does not occur but evidence suggests that fish kills are becoming more severe and more frequent.

The development of a Water Quality Monitoring Strategy for the Richmond River Estuary as part of the Management Study and Plan, provides the basis for an integrated approach to this facet of the estuary (see Appendix 3).

4.3 Data review

A detailed review of existing water quality data from the Richmond River floodplain and estuary (ABER 2008) has been used to characterise water quality and key processes in each of the management zones. Summary statistics (boxplots) have been presented showing the temporal variation in water quality at each site.

4.4 Flow weighted assessments

The results of water quality data review have been synthesised for low (<10%ile flow), median and high flow (>90%ile flow) scenarios into a risk assessment matrix. This is to recognise the important distinction between processes affecting water quality under different flow scenarios.

4.5 Catchment modelling

An E2 catchment export model of the Richmond River catchment recently developed by the Department of Environment and Climate Change and Water (DECCW) was used to provide estimates of hydraulic and pollutant loadings from a total of 49 subcatchments. Runoff was estimated by scaling measured river flow from available stations in upper sub-catchments to total catchment area (source NSW DWE).

4.6 Estuarine response model

An estuarine response model (ERM) of the Richmond River Estuary has been developed to estimate the relative impact of management zone exports on the health of the Richmond River Estuary. It is also used to assess critical thresholds (guidelines) for primary water quality drivers (e.g. light climate and nutrient concentrations) necessary for maintaining key ecosystem processes.

The model is based on a modified 1D box model approach, comprising 13 boxes from the mouth at Ballina to the upper limit of salt penetration at Coraki (Figure 4.1). The transport / mixing sub-model accounts for variation in the principle drivers of estuarine biogeochemical processes:

1. morphology and depth
2. freshwater inflows
3. tidal mixing
4. water residence times (eg Figure 4.2)
5. nutrient and TSS inputs
6. light climate

The biological response sub-model predicts the growth and biomass of phytoplankton and benthic microalgae, as well as rates of bacterial breakdown of organic matter. The net impacts on important water quality parameters such as dissolved oxygen are then estimated.

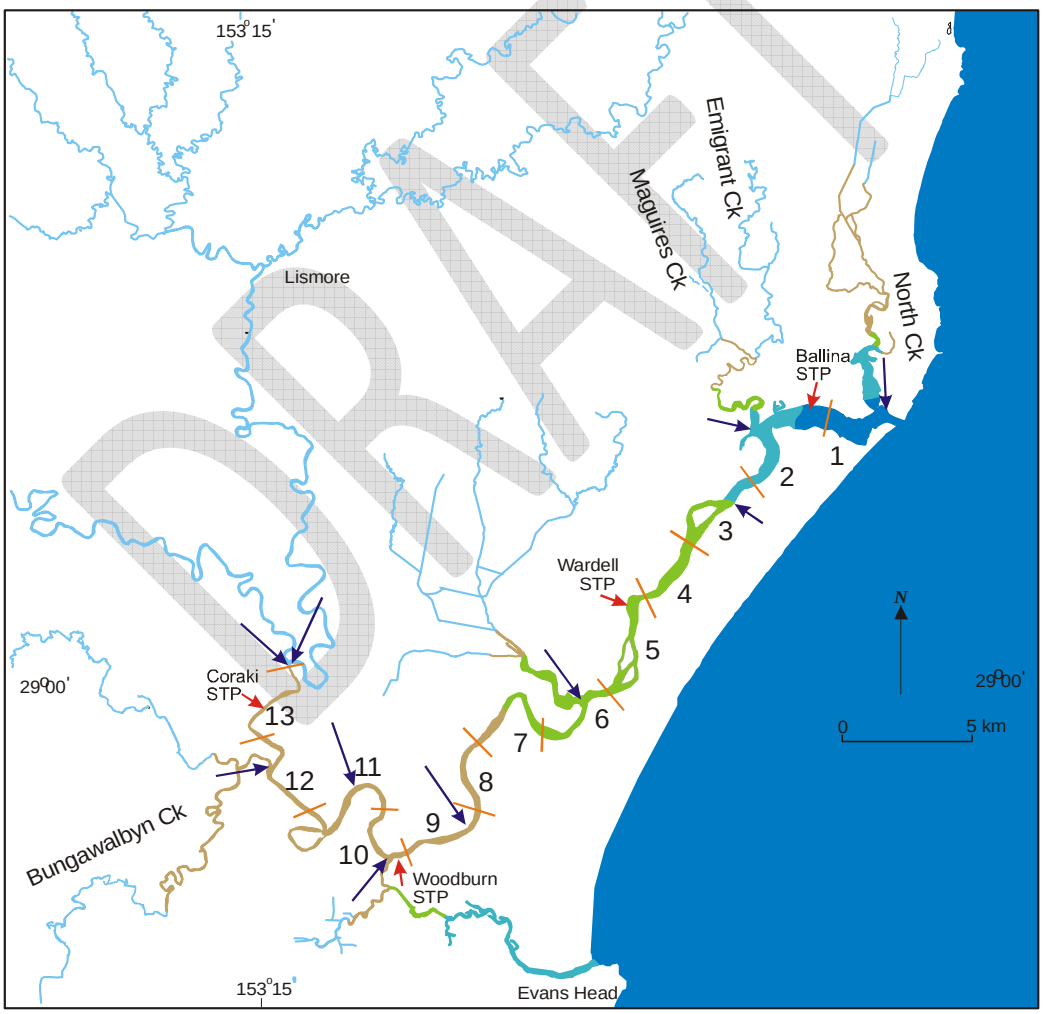

Figure 4.1; The location of box boundaries in the Richmond River Estuary Ecosystem Response Model (ERM), showing inputs of freshwater (blue arrows) and STP effluent inputs (red arrows).

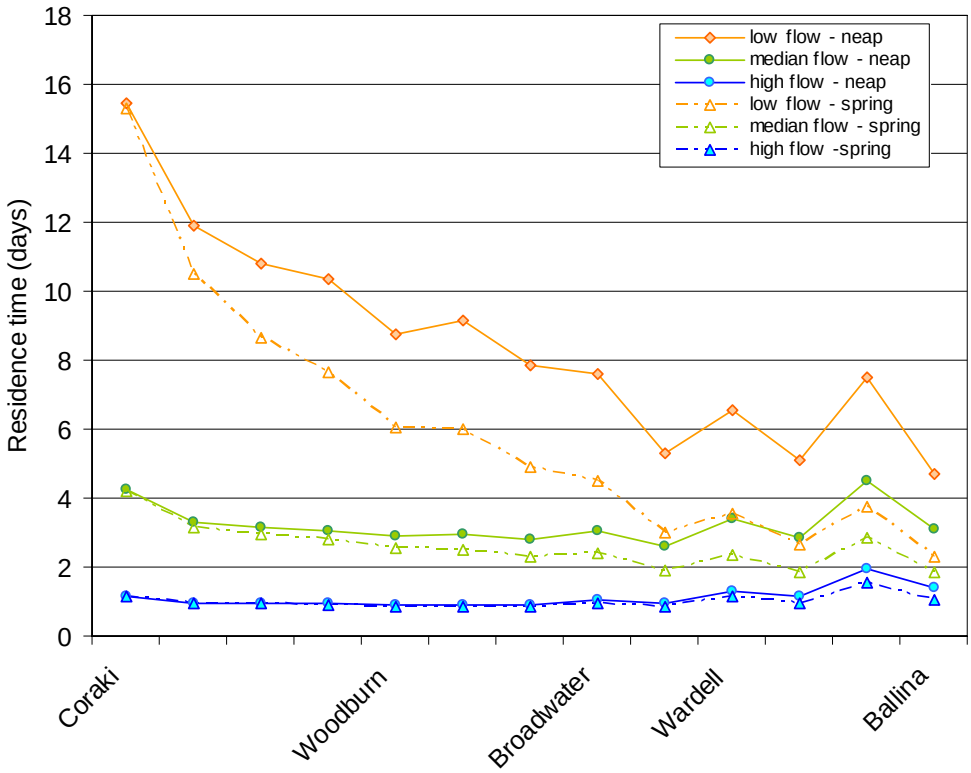

Figure 4.2 ERM estimations of water residence times in each of the 13 boxes along the Richmond River estuary for mean low flow, median and mean high flow conditions during neap and spring tides.
(*neap = a less than average tide occurring at the first and third quarters of the moon*)

4.7 In-stream and downstream impacts

All management zones include significant streams and aquatic habitat which form ecological extensions of the main Richmond River Estuary. These waterways are herein referred to as "in-stream", and associated water quality and threats for in-stream habitats are assessed as distinct from the "downstream" impacts / threats of management zone exports on the main Richmond River estuary. This recognises the ecological importance of smaller tributaries despite their relatively small impact on receiving water quality. In addition, the quality of exports from these in-stream waterways is commonly largely attenuated / modified by internal biogeochemical processes. As such, the maintenance of these processes that may be location-specific, is important to mediating downstream impacts.

4.8 Internal processes

The water quality assessment identifies key reaches / waterways within management zones where internal processes are an important consideration in the maintenance of good water quality and ecosystem health. The main concepts underpinning this analysis are outlined below.

4.8.1 Productivity and ecosystem function

The relative importance of pelagic (water column) and benthic (sediments) habitat is assessed in relation to each components contribution to internal primary productivity (i.e. photosynthesis) within each reach. Where possible this has been quantified using the ecosystem response model. The balance between pelagic and benthic productivity is an important feature of estuarine ecosystems, influencing the type of foodchains present and also the internal recycling of nutrients.

4.8.2 Internal nutrient recycling

Internal deposition and recycling of materials (i.e. water quality constituents) within the waterway can significantly alter water quality. For example, the development of phytoplankton blooms can completely remove all inorganic nutrients from the water column (even in highly enriched systems), and cause large fluctuations in dissolved oxygen. Bio-available nutrients can be released as organic matter (e.g. phytoplankton) is broken down by bacteria in the water column and sediments. A certain proportion of re-mineralised nutrients can be lost due to burial, or in the case of nitrogen, lost to the atmosphere via denitrification.

The relative importance of internal processes increases with water residence times (or "flushing times"), which in turn broadly increase as a function of 1) decreasing antecedent rainfall totals, and 2) distance upstream from the estuary mouth. Channel morphology and impediments to tidal exchange also impact on water residence times.

4.8.3 Light climate

The amount of light reaching the water surface (which is influenced by riparian vegetation cover), and the light attenuation properties of the water and its constituents (as measured by secchi depth) are fundamental controls over the productivity and nutrient recycling characteristics of the system. Both pelagic and benthic compartments can become light limited in turbid water. When sediments become light limited, production by benthic microalgae approaches zero and benthic processes become dominated by bacterial breakdown of organic matter. In extreme cases of eutrophication, this can exert a significant oxygen demand on the overlying water and cause hypoxia.

4.8.4 Eutrophication

The term eutrophication refers to an increase in the rate of organic matter supply in aquatic ecosystems. This can be caused by nutrient enrichment stimulating algal blooms, or large loadings of organic matter or BOD. Eutrophication can significantly alter the quality of pelagic and benthic habitat due to the occurrence of hypoxia and high concentrations of toxic nutrients (e.g. nitrite), and in extreme cases cause permanent shifts in divers ecological communities towards simpler, microbial dominated assemblages.

5 Fauna

The Richmond River Estuary forms part of the greater Moreton Bioregion which is recognised as having high biodiversity. This is because of the high variability in habitat with influences from both tropical climates to the north and temperate climates to the south.

Before the commencement of agricultural practices in the Richmond River catchment and other areas, much of the lower catchment consisted of extensive wetlands. To enable agricultural production, wetlands were drained and cleared of native vegetation. This reduced large amounts of habitat for native fauna, compressing their range significantly and excluding some species altogether. It is estimated that 106,000ha of terrestrial vegetation has been cleared since European settlement in the Richmond valley (SoE 2000 Richmond Valley Council 2003).

This period of change for the area also resulted in the mobilisation of acid sulfate soils that underlay much of the floodplain. Mobile chemicals resulted in reactions and processes that created conditions that were toxic to fish and other aquatic life (eg fish kills). Sometimes acidic water enters the estuary, while at other times black water enters from large stagnant waterbodies upstream. Both these conditions have major impacts on aquatic fauna and other connected species.

The Richmond River Estuary Processes Study (WBM 2006) identified likely impacts on aquatic fauna (including plankton, algae, invertebrates and fishes) from variations in water quality. Similar impacts are likely up the foodchain for marine birds and mammals. It is important to reiterate the connectivity of the estuary to other regions, especially in terms of organisms that travel larger distances, are migratory or have larger home ranges.

There is considerable community value placed on marine mammals such as whales, dolphins and dugongs, as well as many species of bird that inhabit both the estuary and the greater surrounding region. Improvements in the condition of the estuary will increase the available habitat for these species in the future and reduce the risks to their continued existence.

5.1 Summary

There are many species of wildlife present within the estuary, in both aquatic and terrestrial ecosystems. Species are resident, transitory and migratory for the area. The condition of the estuary reflects directly on its capacity to provide adequate habitat for wildlife. For example, in the past Dugongs were frequent in the waterways, however, with the reduction in sea grass and the increase in boat traffic and other impacts, Dugongs have not been recorded within the estuary for some years.

Recommendations towards reductions in threats to fauna have been addressed in Part 2, the Richmond River Estuary Management Plan, for each Management Zone as appropriate. Appropriate actions may be included in other activities such as riparian revegetation, weed control, boat speed control, improvements to water quality, etc.

5.2 Threats to fauna

Apart from the abovementioned water quality changes and threats there are also barriers to movement that threaten ordinary life functions of aquatic mammals and other fauna. The estuary areas provide extremely important feeding and breeding grounds for fish, birds and other fauna. Wetlands are biodiversity hotspots, with large numbers of insects and therefore insect-eating fauna (eg birds, bats, flying foxes, reptiles, etc.).

One of the most important threats is the loss of connectivity between biomes (ie ocean to floodplains to rainforests to mountains). The importance of corridors that allow genetic connectivity and passage for many different species, cannot be over-emphasised.

Environmental issues identified by the NSW NPWS (2008) that threaten flora and fauna, include:

- Climate change and water
- Pollution and contamination
- Pests and weeds
- Waste

The list of Key Threatening Processes in NSW identified by the NSW NPWS Scientific Committee that are relevant to this Study are:

- Alteration to the natural flow regimes of rivers, streams, floodplains & wetlands - key threatening process listing
- Cane toad - key threatening process listing
- Clearing of native vegetation - key threatening process listing
- Death or injury to marine species following capture in shark control programs on ocean beaches - key threatening process listing
- Entanglement in or ingestion of anthropogenic debris in marine and estuarine environments - key threatening process listing
- Exotic vines and scramblers - key threatening process listing
- Human-caused climate change - key threatening process listing
- Invasion of native plant communities by bitou bush and boneseed - key threatening

process listing

- *Lantana camara* - key threatening process listing
- Loss of Hollow-bearing Trees - key threatening process determination
- Predation by feral cats - key threatening process listing
- Predation by the European red fox - key threatening process listing
- Predation by the plague minnow (*Gambusia holbrooki*) - key threatening process listing
- Removal of dead wood and dead trees - key threatening process listing

5.3 Endangered Species

The NSW *Threatened Species Act* (2003) identifies 41 threatened species as occurring or likely to occur in the Richmond River Estuary or nearby. Of these, 33 were listed as vulnerable and 8 as endangered. Priority actions for recovery of these species have been developed (NPWS Threatened Species Unit 2005). The listed endangered species are provided in Table 5.1 below (NSW NPWS 2008):

Table 5.1: NPWS Endangered Species listing for Northern Rivers CMA region and marine region.

Common Name	***Scientific Name***
Birds	
Beach Stone-curlew	*Esacus neglectus*
Gould's Petrel	*Pterodroma leucoptera leucoptera*
Little Tern	*Sterna albifrons*
Southern Giant-Petrel	*Macronectes giganteus*
Wandering Albatross	*Diomedea exulans*
Mammals	
Blue Whale	*Balaenoptera musculus*
Dugong	*Dugong dugon*
Reptiles	
Loggerhead Turtle	*Caretta caretta*

5.4 Vulnerable Species

Vulnerable species that are known to occur or are likely within the study area are provided in Table 5.2 (NSW NPWS 2008).

Table 5.2: Vulnerable species list (NSW NPWS database 2005)

Common Name	*Scientific Name*
Birds	
Antipodean Albatross	*Diomedea antipodensis*
Black-browed Albatross	*Thalassarche melanophris*
Black-tailed Godwit	*Limosa limosa*
Black-winged Petrel	*Pterodroma nigripennis*
Broad-billed Sandpiper	*Limicola falcinellus*
Flesh-footed Shearwater	*Puffinus carneipes*
Gibson's Albatross	*Diomedea gibsoni*
Great Knot	*Calidris tenuirostris*
Greater Sand-plover	*Charadrius leschenaultii*
Grey Ternlet	*Procelsterna cerulea*
Kermadec Petrel	*Pterodroma neglecta*
Lesser Sand-plover	*Charadrius mongolus*
Little Shearwater	*Puffinus assimilis*
Masked Booby	*Sula dactylatra*
Northern Giant-Petrel	*Macronectes halli*
Osprey	*Pandion haliaetus*
Pied Oystercatcher	*Haematopus longirostris*
Providence Petrel	*Pterodroma solandri*
Sanderling	*Calidris alba*
Shy Albatross	*Thalassarche cauta*
Sooty Albatross	*Phoebetria fusca*
Sooty Oystercatcher	*Haematopus fuliginosus*
Sooty Tern	*Sterna fuscata*
Terek Sandpiper	*Xenus cinereus*
White Tern	*Gygis alba*
White-bellied Storm-petrel	*Fregetta grallaria*
Mammals	
Australian Fur-seal	*Arctocephalus pusillus doriferus*
Humpback Whale	*Megaptera novaeangliae*
New Zealand Fur-seal	*Arctocephalus forsteri*
Southern Right Whale	*Eubalaena australis*
Sperm Whale	*Physeter macrocephalus*

Common Name	*Scientific Name*
Reptiles	
Green Turtle	*Chelonia mydas*
Leathery Turtle	*Dermochelys coriacea*

5.5 Recovery Plans

Recovery Plans exist for the Gould's Petrel and the Little Tern, both listed as Endangered under NSW legislation. There are Threat Abatement Plans under development for many species and areas, including Bitou bush and Boneseed, and predation by plague minnow and red fox.

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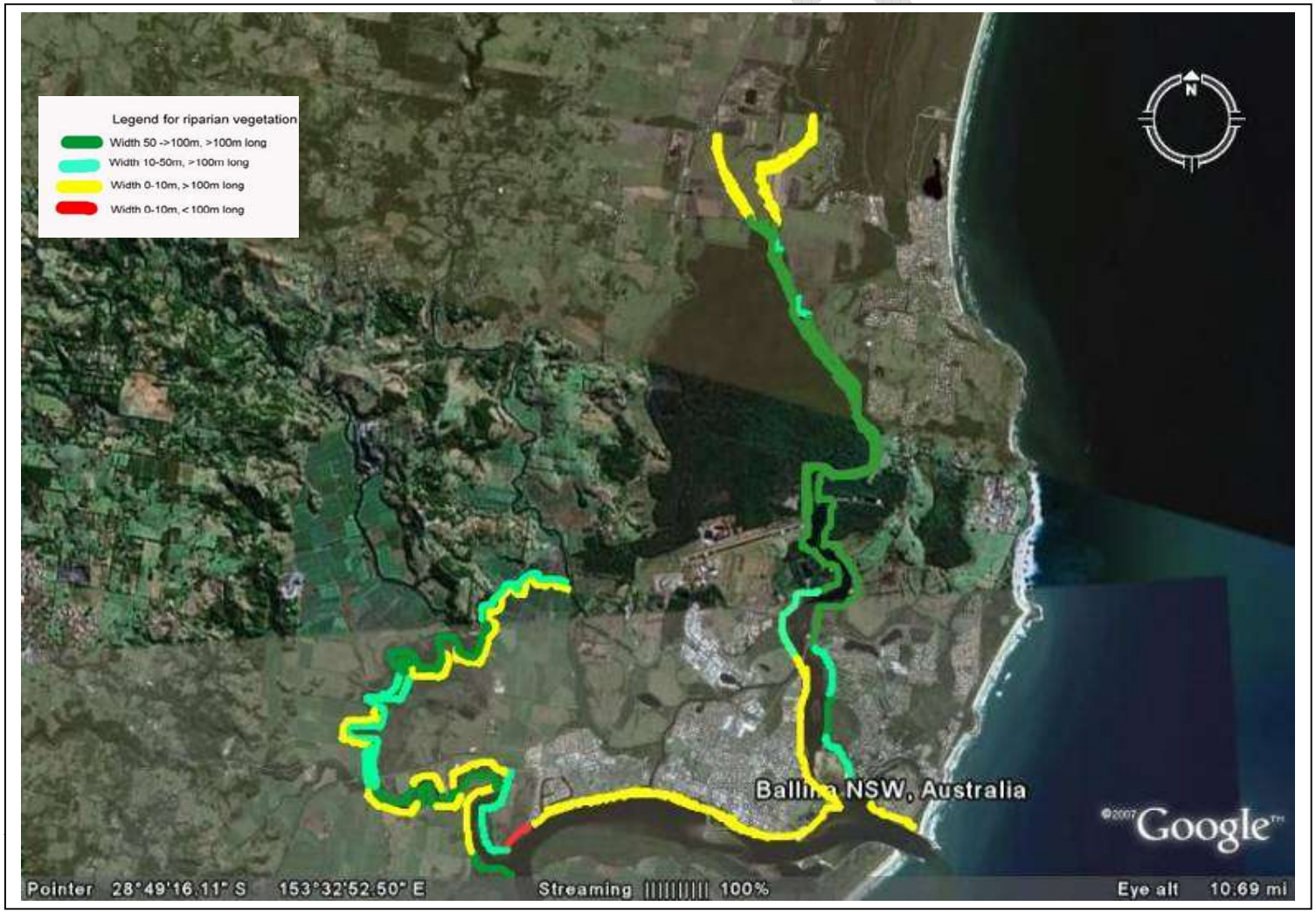
7 Appendices

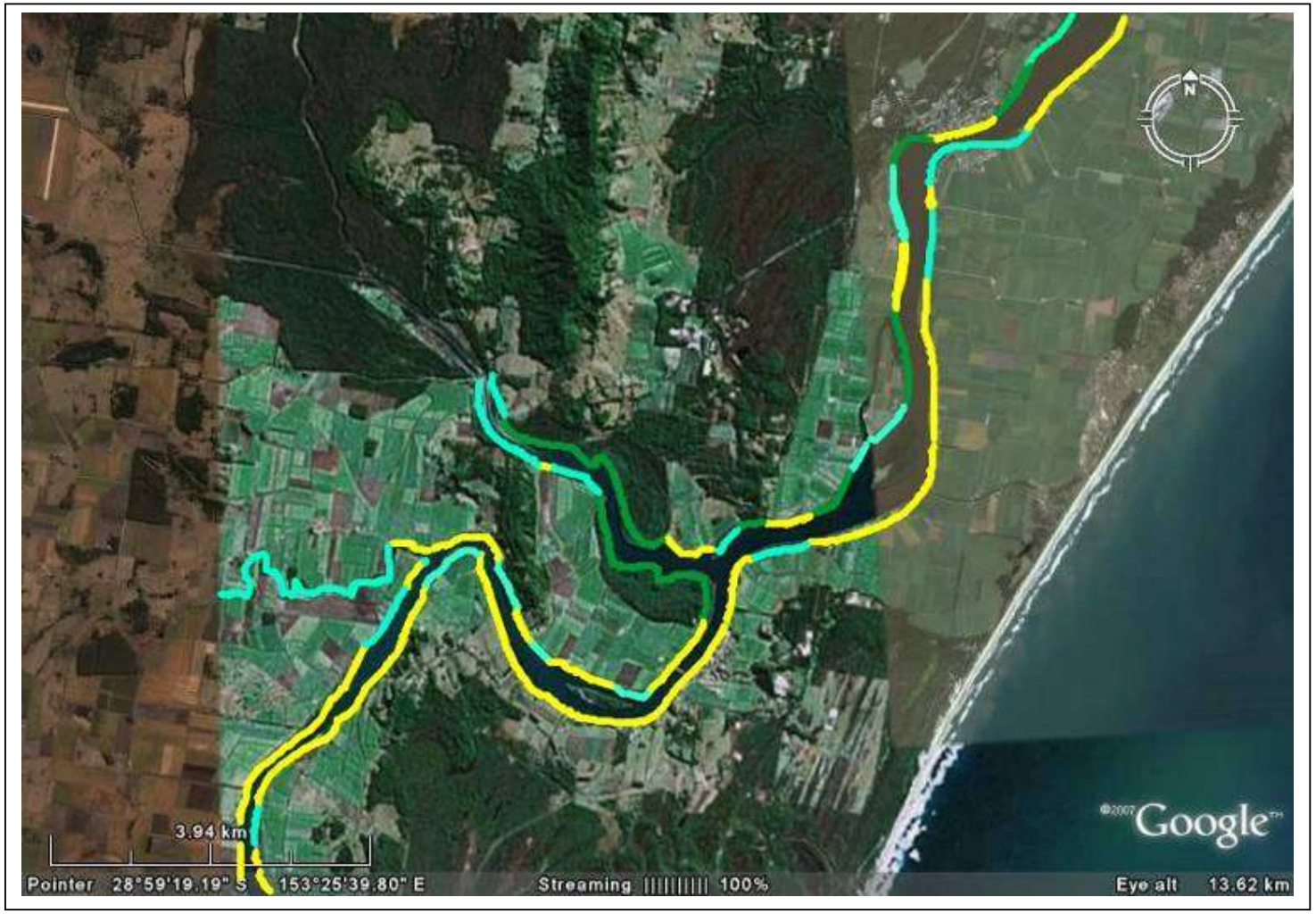
1 – Riparian vegetation assessment maps
2 – Photographic archive of assessment points for water quality, riparian vegetation and geomorphology
3 – Water Quality Monitoring Strategy

Appendix 1 – Riparian Vegetation Assessment Maps

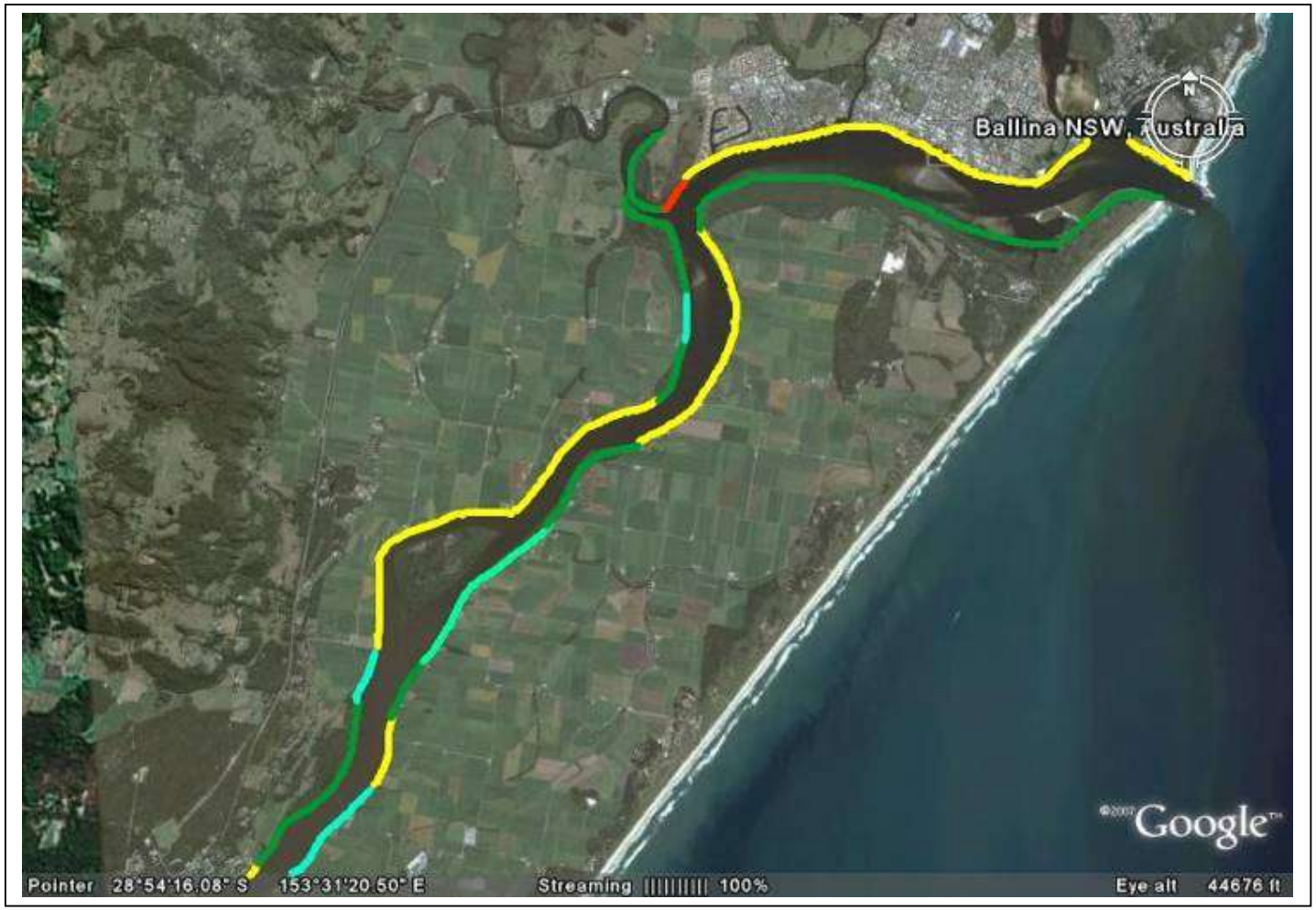
Using aerial photography and on-ground assessment, the following maps have been compiled to depict riparian vegetation width, with green being the widest (50-100m)and blue next widest (10-50m). Yellow areas show width less than 10m over a distance greater than 100m and red areas are less than 10m wide and less than 100m long.



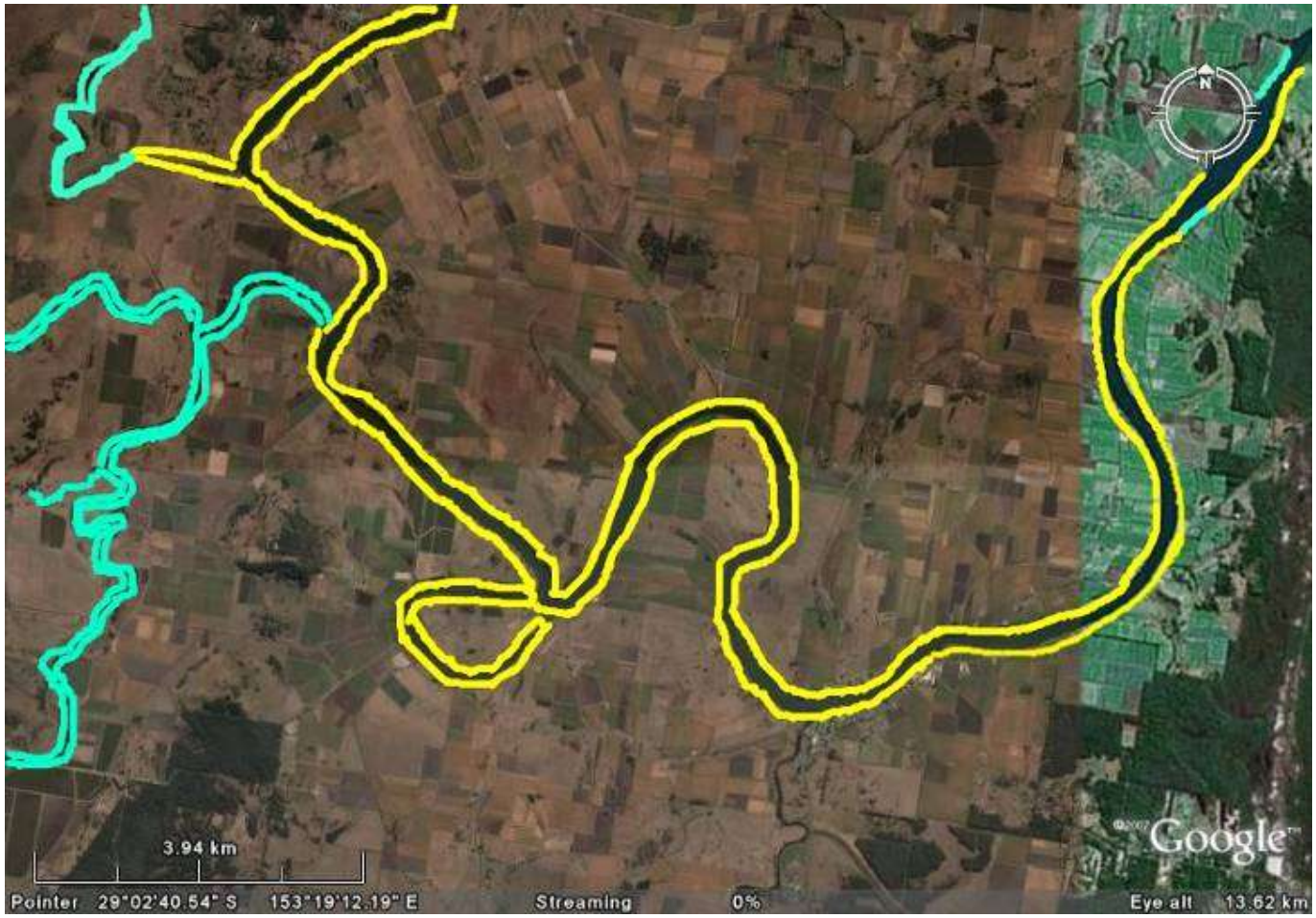
Desktop riparian assessment of the North Creek and Emigrant Creek area.



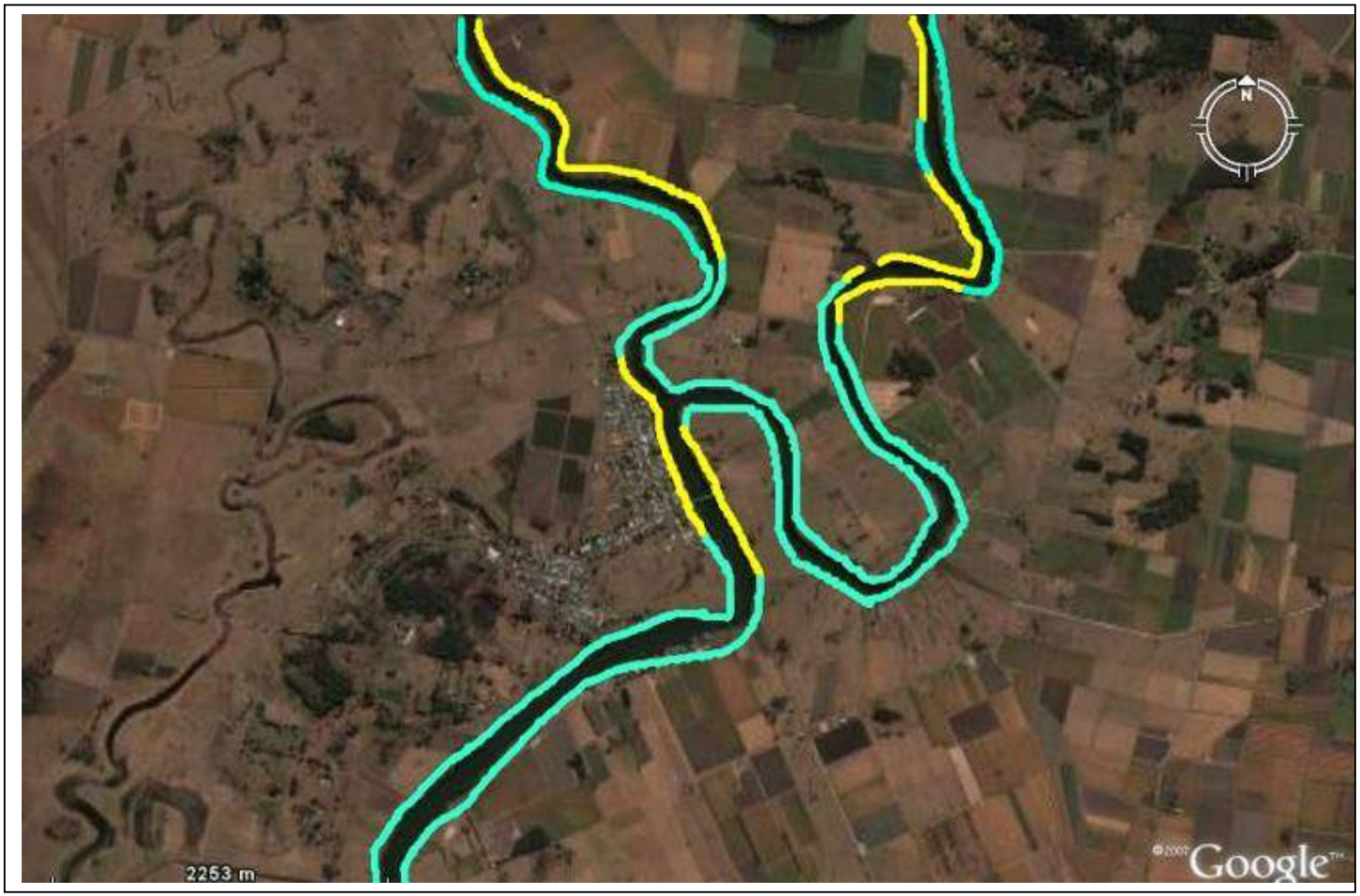
Tuckean – riparian vegetation width and longitudinal connectivity.



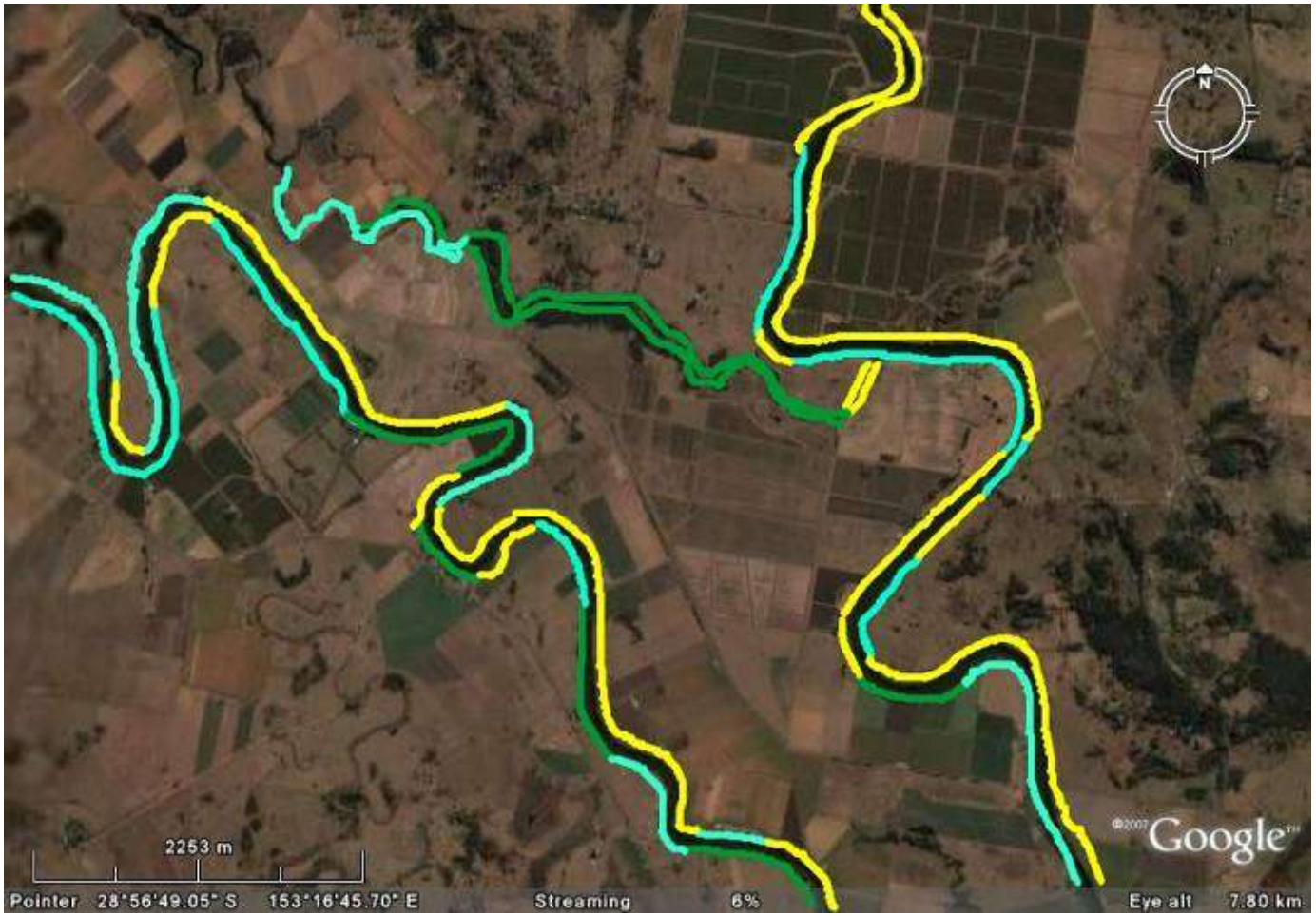
North Creek and Emigrant Creek – riparian vegetation width and longitudinal connectivity



Swan Bay and Bungawalbyn riparian desktop assessment.



Coraki area riparian desktop assessment.



Riparian desktop assessment upstream from Coraki.

Appendix 2 – Photographic Archive for water quality, riparian vegetation assessment and geomorphological assessment points

Zone 1 – North Creek

	
Mangrove regrowth near Ballina Fair	Sediment deposition and mangrove communities lower North Creek
	
Seagrass and mangroves lower North Creek	Public access to foreshore near Missingham Bridge. Note the shoaling from marine derived sediments in the background and rock retaining wall.

	
Recreational fishing in North Creek	Floodplain area and T-tree plantation in the background of picture adjacent to eroding shoreline in North Creek

	
Wet pastures near NC2	Sugar cane at Ross Lane near NC2
	
An Estuary Management Plan was adopted by Ballina Council for Shaws Bay in 2000	Plumes from flood events can extend some distance out to sea.
	
Flood waters at the mouth of North Creek during February 2008.	Fish kill clean up in Ballina Keys February 2008 (Photo: NSW Fisheries)

Figure : Site NC1 and NC2

Zone 2 –Emigrant/Maguires Creek

	
Macadamia plantation on the floodplain near Teven in background. Note bank erosion Maguires Creek.	Development of macadamia plantation on land previously farmed for sugar cane. Teven/Tintenbar.
	
Confluence of Maguires Creek and Houghlahans Creek near Teven Golf Course. Note erosion scarp.	Tyres dumped near Pimlico Island. Perhaps crude attempts at bank stabilisation.
	
Bank slumping and weed infestation at Teven Bridge, Maguires Creek.	Dirt road and exposed bank at the causeway over Pearces Creek, Pearces Creek Hall Road.

	
Degraded wetland near the site of the Teven interchange of the Pacific Highway upgrade.	Water Hyacinth deposition and dead fish near Byrnes Point ferry after the fish kill in February 2008.

	
Google image of the site	Mangrove recruitment
	
Pimlico Island	Drainage into Richmond River
	
Bank slumping and rock retainment.	View of the shoreline.

Zone 3 –Back Channel

	
Wardell Bridge (Pacific Highway)	Tea-tree plantation
	
Vegetation clearing	

	
Google image of the site	River bank at Royal Hotel Wardell
	
Transport of water hyacinth during flood events occurs in the Richmond River.	Erosion control at Wardell

Site BC8 (Northern bank at Wardell).

Zone 4 –South Ballina/Empire Vale

	
Vegetation die back and erosion at Mobbs Bay (Photo: Michael Wood)	Prickly Pear infestation at Mobbs Bay (Photo: Michael Wood)
	
Construction of recreational facilities at Woodburn. The 2008 flood results in bank undercutting of the bank below the steps.	Broadwater Sugar Mill
	
Mangrove Removal on Plenkovich Road	Mangrove colonisation in areas around drains

	
Google Image of the site	Improvement in water quality will result in aquatic habitat values.
	
Over hanging vegetation provides good habitat for aquatic life.	A collaborative water quality project is currently underway at this site.
	
A good riparian zone exists here that is not confined by the road. Weed management is required.	Well structured riparian vegetation.

Images taken from Site SB5.

	
Google image of the site	Drain at Carney Lane
	
Mangroves mixed with grasses	Rover bank vegetation
	
Steep banks at the drain entrance to the river.	Opportunity exists for some vegetation enhancement.

Images taken from Site SB6

	
Mangroves at site SB4	Opportunities for riparian revegetation in the channel at site SB4.
	
Bank slumping resulting in mangrove destablilisation at Wardell. Site BC8 (Southern Bank opposite Wardell)	The extent of bank slumping at this site is significant. Site BC8 (Southern Bank opposite Wardell)

Images from sites SB4 and BC8 (Southern bank opposite Wardell).

Zone 5 –Rileys Hill

	
Improvement works could be conducted on the boat ramp at Rileys Hill (north side)	Steep bank at the boat ramp (south side)
	
Wetlands on private property with habitat value.	A pair of Brolgas was observed in the same wet pasture site on 9/4/08 and later on the 25/09/08.
	
Works being conducted to elevate land adjacent to the river	Tea-tree (mid ground) and sugar cane (far background) are both grown at Rileys Hill.

Zone 6 –Evans

	
Riparian vegetation north of Woodburn limited by the current highway	Opportunity exists for high profile riparian revegetation and weed management along the river bank at Woodburn.
	
Bank erosion on Tuckombil Canal (Site E19).	Tuckombil Canal joining the Richmond River to the Evans River (Site E19)
	
Coral Tree invasion on the lower river bank at Tuckombil Canal (Site E19)	Limited riparian vegetation at the Tuckombil Canal site (Site E19)

An overview of images from Management Zone 6 –Evans and on ground assessment site E19

Zone 7 –Rocky Mouth Creek

	
Google image showing the area of site RC17	
	
Narrow riparian zone being used as a horse paddock at site RC17. Note the coral tree weed abundance. This landowner expressed interest in riparian revegetation	Weed infestation along Rocky Mouth Creek site RC17

An overview of images from Management Zone 7 –Rocky Mouth Creek and on ground assessment site RC17.

Zone 8-Swan Bay

	
Google image of the Swan Bay area	
	
Riparian zone near Swan Bay showing extensive coral tree growth and exotic vines.	Richmond River in April 2008 after heavy rains near Swan Bay.
	
Sand extraction from the Richmond River near Swan Bay	Riparian vegetation at Swan Bay.

	
Terrestrial and aquatic vegetation at site	Shore line reeds
	
Wetland habitat with some weed aquatic weed issues	Mixed species of aquatic plants

Images from site SB20

Zone 9-Kilgin Buckendoon

	
Kilgin Canal	Some large native eucalyptus on the riparian zone.
	
Some areas of riparian vegetation exist with notable native trees. Extent is limited by the road in places.	
	
Vegetation clearing resulting in bank erosion	Large improvements to riparian zone can be made in high profile areas like Council managed parks. (Woodburn west bank)

	
Riparian vegetation clearing (April 2008) destroyed native trees including Tuckeroos.	Good riparian vegetation cleared for unknown reasons (April 2008).
	
Dungarubba Creek restoration project	The boat ramp at Dungarubba Recreational Reserve needs improvement
	
Dungarubba Drain feeds into Dungarubba Creek restoration project	Riparian farming

	
Kilgin School Canal entrance to the Richmond River	Recent fill dumping and vegetation clearing at the Kilgin School Drain entrance (April 2008)
	
Richmond River at site KB13/14	Aquatic plants in the drain
	
Muddy sediments at the drain entrance	Vegetation on the toe of the bank

Images from site KB 13/14

	
Google image of this site	Extensive grazed riparian area note coral tree
	
Hugh potential exists for revegetation with limited weed removal required. Need land holder support for this site.	Weed invasion in grazing paddock
	
Cattle grazing in the riparian zone	Some good riparian vegetation upstream from this site.

Images from site KB15

	
Google image of this site	Bank slumping on opposite bank
	
Limited riparian vegetation at this site (opposite Bank)	Floating weeds and sparse riparian vegetation
	
Rocks used to retain bank and tree pruning is evident.	Riparian vegetation on Oakland Road bank

Images from site KB18

Zone 10 - Tuckean

	
Upstream from the Baggotville Barrage	The Tuckean is utilised by wetland birds.
	
Variable riparian vegetation along the channels	Mangrove fern at the Baggotville Barrage
	
The Baggotville Barrage	

	
Google earth image of the site	Good riparian vegetation structure
	
Rock revetment and mangrove colonisation.	Interesting depositional area near the cutting edge of the bank. Note aquatic weeds.
	
Stormwater runoff and floodplain drainage at this site	Good native riparian trees

Images from site T11

	
Google image of the site	Rocky outcrop on the northern side of the barrage inhibits immediate erosion. Downstream erosion is notable (background)
	
Abundant water lilies on the estuary side of the barrage.	Southern side of the barrage on the estuary side
	
Northern side of the barrage	

Images from site T12

Zone 11-Bungawalbyn

	
Drainage channel through pasture	
	

	
Riparian revegetation	
	
Drain management	Asparagus fern regrowth
	
Steep banks with some good native trre growth. The width of the riparian zone is limited.	

Images from site BU26

	
	
Active riparian revegetation	Landholder commitment to riparian vegetation enhancement.
	

Images from site BU27/28

Zone 12 –Upper Richmond/Wilsons River

	
Confluence of Leycester Creek and Wilsons Rivers at Lismore	Cattles access to streams enhances erosion, Wilsons River near Eltham.
	
Pelican Creek	Near the sale yards at Leycester Creek
	
Confluence of the Richmond and Wilsons River at Coraki	Exposed banks and bank slumping at Lismore.

	
Wyrallah boat ramp	Large area of exposed bank at the Wyrallah boat ramp
	
An interesting wetland site occurs near site 24.	Foreshore works in Lismore has been conducted as part of the levee construction.
	
Jabiru Geneebeinga wetlands are near Casino. Opportunities exists to protect further wetland refuge areas.	Turbidity is compromised during rainfall events in the Wilsons Creek at Bangalow, far upstream from the study area.

	
Camphor Laurel a large woody weed prominent in the management zone. Although a noxious weed they provide structural support for the riparian zone.	Cattle fencing and riparian revegetation on the Wilsons River.
	
Coral tree infestation along the Wilsons River near Lismore. Some structural support is provided b these weeds.	Riparian weed issues, Wilsons River.
	
Severe bank slumping, Wilsons River.	Slumping causing tree fell into the River, Wilsons River.

	
	Water extraction at the Lismore Source has the potential to compromise downstream water quality.

	
A google image of the site	Cattle access to the river on opposite bank at Coraki
	
Public space on the river bank at Coraki	Fishing at the boat ramp in Coraki
	
View from the bridge downstream from Coraki	Fill dumping at the playground in the river side park, Coraki.

Images from site 21/22

	
A google image of this site	Some serious weed issues at this site
	
River extraction on the opposite bank at this site.	Post flood mud deposition at this site
	
Play ground and BBQ facilities are at this site. Some tree planting (background) and grass swales are used to divert rainwater to the river.	I view from the bridge at this site.

Images from site 23

	
A google image of this site.	
	
Grazing occurs at this site	Riparian grazing land with coral tree infestation on the river bank.
	
Some structural vegetation occurs at this site among intermittent exposed river bank areas.	Private riparian land

Images from site 24

	
A google image of the site.	Dairy cattle access to the river has been controlled at this site.
	
	Some weed management would benefit this site.
	
Willing landowner at this site provide possible further riparian management. Upstream of site	Downstream view at this site

Images from site 25

	
A google image of this site	Downstream from the bridge
	
Upstream of the bridge	The swing ropes indicate that primary contract recreation occurs at this site.
	
Weed issues at this site	Opportunities for riparian vegetation enhancement.

Images from site 29/30

	
A google image of this site	The Manyweathers Weir at Casino.
	
Riparian vegetation went some way to helping stabilise banks in recent flooding (2008).	Rocky substrate occurs at the foot bridge downstream from the weir. Some notable riparian plant has occurred along the path and Lomandra help stablilise the bank in the foreground.

Images from site 31

	
A google image of the site locality	Downstream of the site
	
Undercutting of banks	Upstream of the site
	
Site vegetation and bank view.	Some threatening vines

Images from site 32

Appendix 3 – Water Quality Monitoring Strategy

Richmond Estuary Monitoring Strategy (REMS)

The Richmond River is predisposed to water quality challenges due to its relatively small catchment area (6979km^2) and large floodplain (990km^2) with a very small water surface area (19km^2). It is a poorly flushed system with a tidal pinch near Pimlico which results in poor water exchange upstream from this area. The upper catchment areas have largely been cleared and the land use is now predominantly agriculture. This change in land use has contributed to high TSS and nutrient loadings from these areas. Additionally, there are eight sewage treatment plants in the study area and several more in the catchment area, which manage waste from the larger urban areas including Ballina, Lismore, Casino, Wardell, Alstonville, Nimbin, Dunoon, and Coraki. Stormwater runoff from these urban areas also enters the Richmond River. The large expanse of rural residential living within the area also results in a significant number of on-site sewage treatment facilities. The labyrinth of road networks and the lack of hard surfaces on some of these also contributes to TSS loading.

The hydrology of the large floodplain has largely been modified through drainage channels and changes in vegetation types. The exposure of Acid Sulfate Soils (ASS) has occurred as a result of floodplain drainage and other activities that altered the ground water hydrology. Flood waters can become acid when draining occurs from large areas of ASS. Blackwater events are significant post flooding in the Richmond River Estuary and Eyre et al. (2006) have determined that at 25˚ the Richmond River floodplain has the potential to deoxygenate 12.5 x 10^3 mL of saturated freshwater. This scale of deoxygenation is sufficient to completely deoxygenate floodwater stored on the flood plain within 3 to 4 days.

Historical information suggests that flood water can persist on the floodplain for around 6 days and in some places for several weeks. Both black water events and acid water event have contributed to fish kills in the Richmond River. There are also potential health risks related to mosquito borne infections after flood events and while water is still stored on the floodplain. Healthy, ecologically balanced wetlands systems can minimise mosquito infestation.

Overview

The aim of this strategy is to provide an optimised, cost-efficient way to:

- Monitor ecosystem health along the estuary (including tidal pools) and tributary waterways on the floodplain,
- Monitor the main drivers of ecosystem health,
- Assess the performance of sub-catchment management initiatives in improving ecosystem health, and
- Interpret data within a functional catchment export-estuarine response model framework that can be used as a predictive risk assessment tool.

Integrated catchment-wide monitoring

The Richmond River estuary is the unifying element for environmental management across all local government areas (LGAs). Each LGA attempts to maintain good water quality throughout their particular part of the catchment and estuary, however, the ultimate goal is to improve the ecosystem health of the Richmond estuary. Monitoring strategies should, therefore, not only cover particular localised issues, but also place these into the wider system context (i.e. how does each LGA impact on the estuary as a whole).

At present, there is monthly water quality monitoring data collected from each of the constituent councils. This data will be used to assist with future monitoring, however, a coordinated approach will provide more robust results.

Centralised approach

Disparate LGA water quality monitoring programs across the Richmond River catchment would be best served by centralising and standardising the collection, storage and analysis of samples to a catchment-wide monitoring strategy. This allows for a standardised approach to sampling protocols, analysis, quality assurance and database management ensuring high quality data. It is important that the strategy is consistent with state-wide monitoring efforts (e.g. the Monitoring, Evaluation and Reporting program currently being undertaken by DECCW 2008).

Organisation

The strategy should be ideally overseen by a single authority (e.g. Richmond River County Council), and include regular consultation with contributing stakeholders. It is anticipated that the strategy could be run by one full-time Water Quality Officer. Time weighting for duties would include:

- Sample collection 0.3
- Sample analysis 0.3
- Data management 0.2
- Reporting and Liaison 0.2

The position would require field, laboratory and data analysis skills. Data quality can be improved keeping the chain of custody from sample collection, storage, analysis to data management with one person. Data would be made available using existing reporting framework for Councils.

Monitoring locations

The choice of monitoring locations will be determined by a trade-off between costs / logistics and information gained. A core set of main channel sample locations should be maintained

along the estuarine gradient and tidal pool in order to provide assessment of system-wide water quality, and a context for gauging impacts of sub-catchment inputs. Ideally, these should include representatives from each reach.

Sampling locations within each sub-catchment unit should include as a minimum a site at the catchment outlet, sites relevant to current management initiatives, and major secondary sub-catchments (e.g. a minimum requirement for the Bungawalbyn / Sandy Creek management unit would be sites in both creeks upstream of their confluence and one site downstream of their confluence). Ideally, a site representative of the primary water quality stressor (e.g. the Bora Codrington drain) should be included. It is anticipated that the strategy would utilise car and boat based sampling to cover the minimum of sites throughout the catchment and estuary.

Boat-based sampling is preferable for estuarine monitoring due to the ability to:

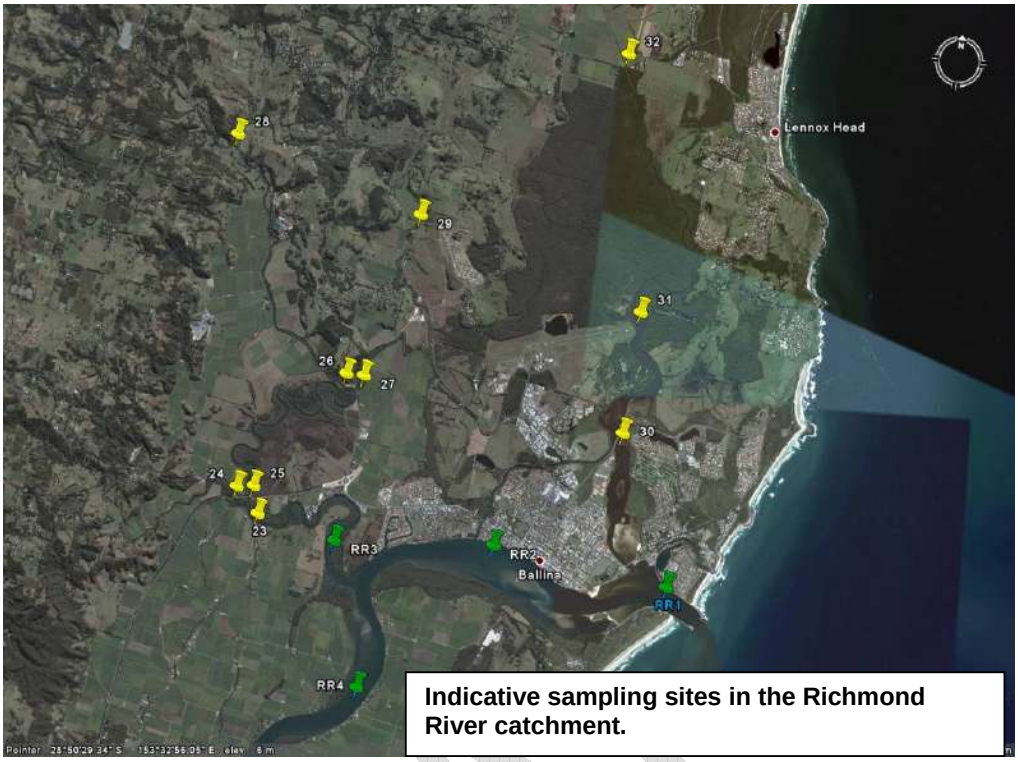
- choose ecologically-relevant sites rather than be constrained by accessibility considerations,
- collect mid-stream samples (away from bank disturbance effects),
- take depth profiles which provide valuable information about stratification,
- allow samples to be collected at a standard state of tide along the estuarine gradient, thereby improving the quality of the data and power of interpretation.

Car-based sampling is required to cover most of the catchment outlet sites. Problems associated with bank-based sampling can be overcome using various remote sampling aids (e.g. extension poles for probes and collection containers), or utilising bridges where appropriate.

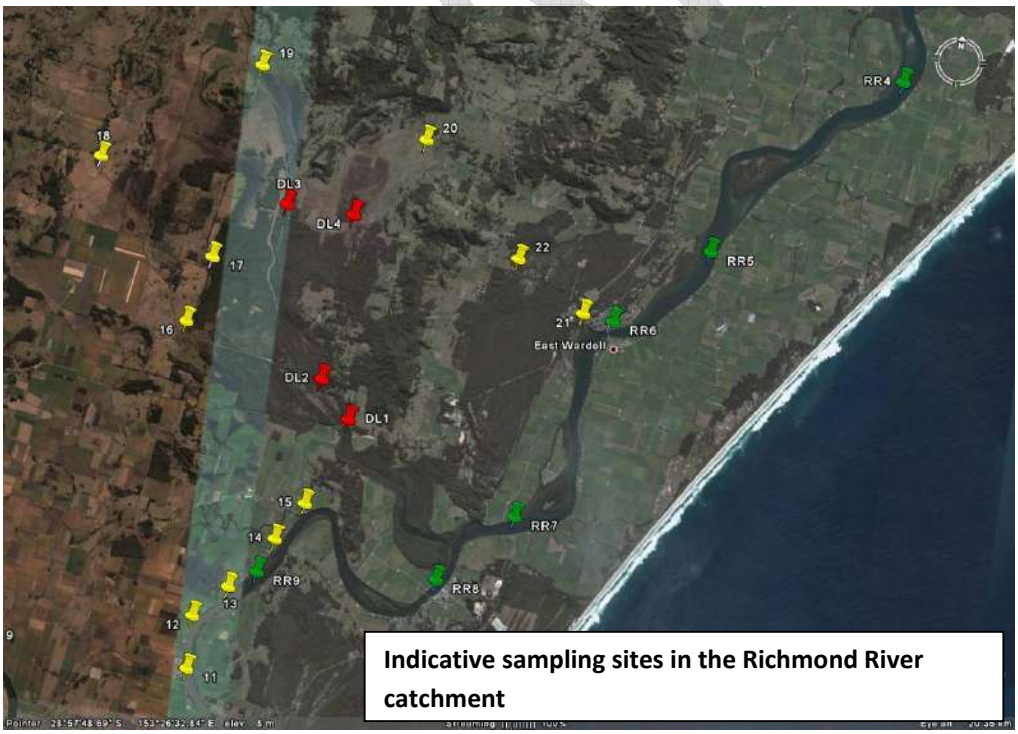
Indicative sites have been identified (Figures 8.1 to 8.4) according to:

- strategic location at key catchment outlets,
- ability to monitor indicators pertinent to management zone issues, and
- ability to monitor indicators relevant to ecosystem health within a reach.

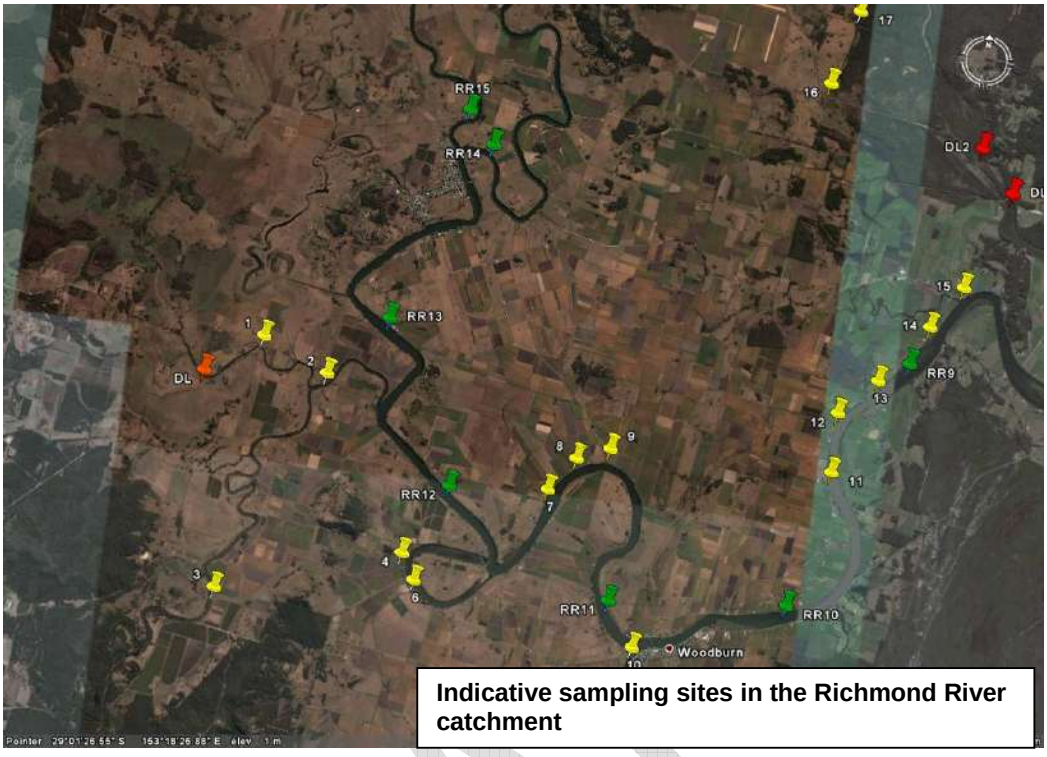
A total of 36 car-based and 15 boat-based sites have been identified, which is approximately 3 car-based and 1 boat-based sample per management zone (note that not all management zones contain equal numbers of sites – number of sites per zone was commensurate with the magnitude of the zones issues).



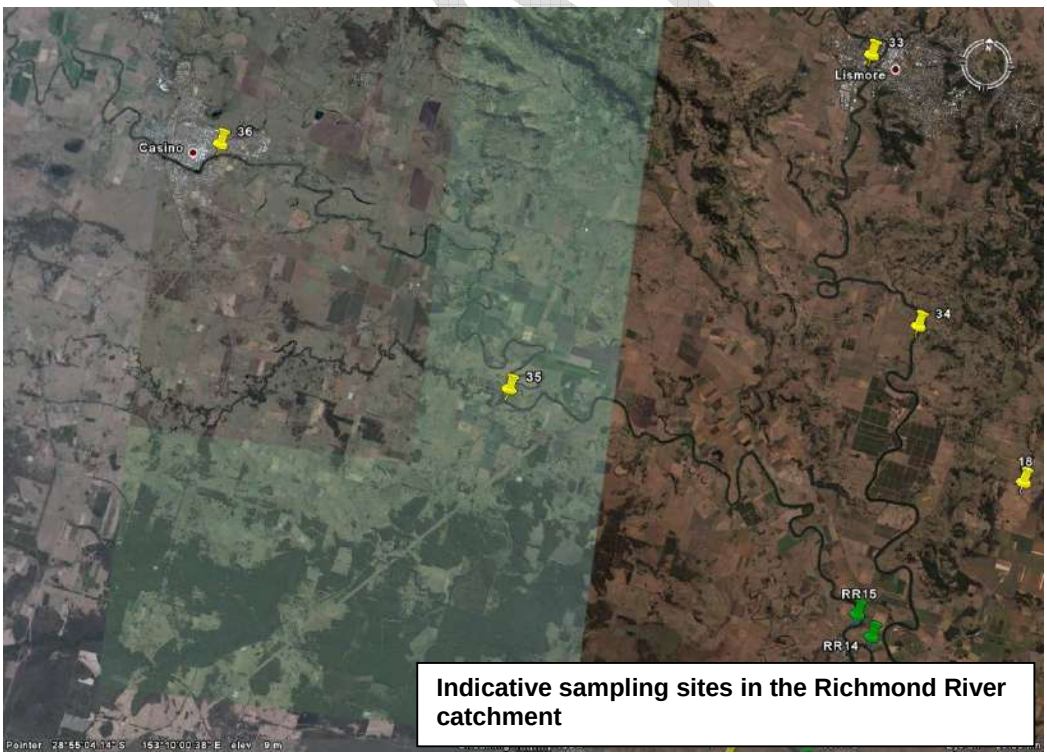
Indicative sampling sites in the Richmond River catchment.



Indicative sampling sites in the Richmond River catchment



Indicative sampling sites in the Richmond River catchment



Indicative sampling sites in the Richmond River catchment

Monitoring frequency

A minimum routine frequency of monthly samples across all locations is required to properly ascertain seasonal trends due to temperature and broader wet/dry seasonal changes, however, it is insufficient to assess the magnitude / persistence of extreme water quality events (e.g. hypoxia) alone. The power of a monitoring strategy to accurately constrain environmental trends increases with the sampling frequency, which needs to consider the time frame of processes which impact on water quality.

Monthly samples will commonly miss the extremes of water quality variation in response to high flow events, and will only provide a coarse measurement of impacts arising from in-stream processes (e.g. algal blooms and subsequent hypoxia). Fortnightly samples are most likely to represent the minimum sampling frequency needed to describe temporal variation in internal processes and reduce the standard error of estimations. In addition, a flow weighted component to the strategy (e.g. revert to weekly samples after major rainfall events) would greatly improve understanding of catchment exports and ecosystem responses to these inputs to the estuary.

Water quality parameters

A full suite of physico-chemical parameters (temperature, conductivity, dissolved oxygen, pH, faecal coliforms and turbidity) should be measured at each site regardless of what other parameters are measured. These provide vital information pertinent to ecosystem health, e.g. salinity regime (and therefore relative freshwater influence), acidity and trophic status (e.g. hypoxia).

The choice of additional water quality parameters should be addressed on a site by site basis, depending on the primary water quality stressors (e.g. ASS runoff and blackwater) relevant to the site. Catchment outlet sites should include collection of samples for organic dissolved and particulate nutrients and inorganic dissolved nutrients, as well as total suspended solids and chlorophyll-*α*.

Quality assurance protocols

A full record sheet should be maintained for every sample collected (see example record sheet attached as Appendix 1).

Due to the uncertainty introduced to data through poor calibration, it is essential that calibration, according to instrument specifications and using certified high quality standards and reference waters, is carried out pre- and post-sampling. These results should be reported in the Richmond River Water Quality Database (RRWQDB) to allow subsequent quality assessments to be made on data. All data should be entered into the RRWQDB as soon as possible and checked for consistency. Any unexplained anomalies in the data should be addressed immediately to ascertain whether the anomaly reflects a methodological

artefact or bona fide environmental trend. These results will be available to all extension officers in real time.

Analytical protocols

To ensure the recovery of good quality data (and hence return for sampling costs), it is critical that all laboratory analysis is NATA certified, and is carried out using the current best-practice methods for marine, estuarine and freshwater water samples. In particular, it is recommended that a low level analysis protocol for inorganic and total nutrients be developed that accounts for interferences due to variable salinity of samples. All analyses should include standard reference materials, and regularly cross check laboratory performance by sending replicate samples to other approved laboratories for analysis.

Data management

Data from the Richmond River Estuary Water Quality Monitoring Strategy (RREWQMS) would be stored centrally in the RRWQDB originally developed by WBM Oceanics as part of the Richmond River Estuary Processes Study. The database currently stores data in Microsoft Access format and provides statistical interpretation via Microsoft Excel and a graphical interface using MapInfo. There is scope for upgrading the current system to make it more user friendly and tailoring outputs to integrate seamlessly with the catchment export and estuarine modelling tools (see below).

In situ data-loggers

These provide valuable information on water quality variation in response to tidal variations, floodgate management, and critical thresholds for the outflow of backswamp runoff. In particular, well-maintained loggers provide crucial feedback on the effectiveness of drain management initiatives (e.g. sills) as long as the data period spans the full range of climatic extremes.

The network of loggers currently maintained in the Tuckean Swamp / Broadwater provides a good system overview by spanning the gradient from the upper, middle, and lower backswamp through to the broadwater. There are major issues associated with *in situ* dataloggers, which must be addressed to maximise the recovery of good quality data:

- Probes should be referenced to AHD to allow proper assessment of tidal impacts and critical levels;
- Probe drift due to biogeochemical fouling should be minimised by regular servicing and calibration,
- If probes are set at a fixed height above the channel bed, an assessment of stratification in the waterway and the potential artefacts likely caused, should be undertaken.

Data analysis and interpretation

Well coordinated REMS could;

- Provide measurable performance indicators for sub-catchment management initiatives (see zone specific indicators in Part 2),
- Improve the diagnostic power of monitoring to detect environmental changes,
- Improve understanding of the Richmond River ecosystem and its likely response to climate change and catchment management scenarios, and
- Meet LGA requirements for environmental audits and reporting.

Catchment export and estuarine response models

The Department of Environment and Climate Change (DECC) has recently completed a comprehensive E2 catchment export model of the entire Richmond River catchment. The model includes up-to-date landuse assessments for each sub-catchment and allows the estimation of pollutant loads from each sub-catchment and testing of landuse change scenarios on loads. This catchment export model has been coupled to an estuarine response model (ERM) of the Richmond estuary which estimates the relative impact of management zone exports on the health of the Richmond estuary. It is also used to assess critical thresholds (guidelines) for primary water quality drivers (e.g. light climate and nutrient concentrations) necessary for maintaining key ecosystem processes.

The model is based on a modified 1D box model approach, comprising 13 boxes from the mouth at Ballina to the upper limit of salt penetration at Coraki. The transport / mixing sub-model accounts for variation in the principle drivers of estuarine biogeochemical processes:

- morphology and depth
- freshwater inflows
- tidal mixing
- water residence times
- nutrient and TSS inputs
- light climate

The biological response sub-model predicts the growth and biomass of phytoplankton and benthic microalgae, as well as rates of bacterial breakdown of organic matter. The net impacts on important water quality parameters such as dissolved oxygen are then estimated.

Interpretation of routine monitoring data

Data collected routinely as part of the proposed REMS can be easily interpreted in the catchment export-ERM framework to give an indication of ecosystem health status against a set of system-specific health guidelines. Catchment outlet data can be used to calibrate and update export coefficients in the E2 model to give more realistic estimations of loads.

Wilsons River

Key monitoring sites and assessment parameters

The following series of Tables provide key monitoring sites and parameters for the assessment of inputs and ecosystem health in Management Zones 1 to 4 and 7 to 12, described in the Coastal Zone Management Study for the Richmond River Estuary and Plan (Australian Wetlands 2009).

ZONE 1 – North Creek	Phys-chem	Secchi	nutrients	BOD	Chlorophyll-*a*	TSS
Input sites						
Newrybar Swamp at Ross Lane	X		X	X		X
Ballina STP	X		X	X	X	X
Ballina urban runoff	X		X	X		X
In-stream health sites						
Upper North Creek estuary	X	X	X		X	X
Mid North Creek estuary	X	X	X		X	X
Lower North Creek estuary	X	X	X		X	X
Lower Richmond estuary	X	X	X		X	X

ZONE 2 – Emigrant / Maguires Creek	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Emigrant Ck at Cumbalum	X		X	X	X	X
Maguires Ck at Teven	X		X	X	X	X
Uralba Ck at highway	X		X	X	X	X
Pimlico Ck at highway	X		X	X	X	X
In-stream health sites						
Emigrant Ck at confluence	X	X	X		X	X
Maguires Ck at confluence	X	X	X		X	X
Emigrant estuary at Pacific Highway	X	X	X		X	X
Lower Emigrant estuary	X	X	X		X	X
Lower Richmond estuary at Byrnes Pt	X	X	X		X	X
Lower Richmond estuary at Pimlico	X	X	X		X	X

Zone 3 – Back Channel	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Bingal Ck at Wardell Rd	X		X	X	X	X
Pacific highway upgrade sites	X		X	X	X	X
Instream health sites						
Bingal Ck at confluence	X	X	X		X	X
Mid Richmond estuary at RR5	X	X	X		X	X
Mid Richmond estuary at RR6	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X

Zone 4 – South Ballina / Empire Vale	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Empire Vale Ck at Reedy Ck Rd	X		X	X	X	X
In-stream health sites						
Empire Vale Ck at outlet	X	X	X	X	X	X
Lower Richmond estuary at RR1	X	X	X		X	X
Lower Richmond estuary at RR2	X	X	X		X	X
Mid Richmond estuary at RR4	X	X	X		X	X
Mid Richmond estuary at RR5	X	X	X		X	X
Mid Richmond estuary at RR6	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X
Mid Richmond estuary at RR8	X	X	X		X	X

Zone 7 – Rocky Mouth Creek	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Rocky Mouth Ck at tide gates	X	X	X	X	X	X
In-stream health sites						
Rocky Mouth Ck at fabridam	X	X	X	X	X	X
Rocky Mouth Ck at Woodburn	X	X	X	X	X	X
Upper Richmond estuary at RR10	X	X	X		X	X
Upper Richmond estuary at RR11	X	X	X		X	X

Zone 8 – Swan Bay	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Northern drain	X	X	X	X	X	X
Southern drain	X	X	X	X	X	X
In-stream health sites						
Swan Bay	X	X	X	X	X	X
Upper Richmond estuary at RR11	X	X	X		X	X
Upper Richmond estuary at RR12	X	X	X		X	X

Zone 9 – Kilgin / Buckendoon / Dungarubba	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Oakland Rd drain1	X		X	X	X	X
Oakland Rd drain2	X		X	X	X	X
Oakland Rd drain3	X		X	X	X	X
Kilgin Rd drain1	X		X	X	X	X
Kilgin Rd drain2	X		X	X	X	X
Kilgin Rd drain3	X		X	X	X	X
Kilgin Rd drain4	X		X	X	X	X
Kilgin Rd drain5	X		X	X	X	X
Instream health sites						
Mid Richmond estuary at RR8	X	X	X		X	X
Upper Richmond estuary at RR9	X	X	X		X	X
Upper Richmond estuary at RR10	X	X	X		X	X
Upper Richmond estuary at RR11	X	X	X		X	X
Upper Richmond estuary at RR12	X	X	X		X	X

Zone 10 - Tuckean	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Yellow Ck at Justilius Rd	X		X	X	X	X
Marom Ck at Tuckean Island Rd	X		X	X	X	X
Tucki Ck at Mathieson Ln	X		X	X	X	X
Instream health sites						
Tucki Drain at Tuckean Island Rd	X	X	X		X	X
Nature Res. Drain at Tuckean Island Rd	X	X	X		X	X
Main drain at Baggotville Barrage	X	X	X		X	X
Mid Richmond estuary at RR7	X	X	X		X	X
Mid Richmond estuary at RR8	X	X	X		X	X

Zone 11 – Lower Bungawalbyn	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Bungawalbyn Ck at Neileys Lagoon Rd	X		X	X	X	X
Instream health sites						
Bungawalbyn Ck at Boggy Ck Rd	X	X	X	X	X	X
Sandy Ck at Myall Ck Rd	X	X	X	X	X	X
Bungawalbyn Ck at Coraki-Woodburn Rd	X	X	X	X	X	X
Upper Richmond estuary at RR12	X	X	X	X	X	X
Upper Richmond estuary at RR13	X	X	X	X	X	X

Zone 12 – Upper Richmond / Wilsons	Phys-chem	secchi	nutrients	BOD	Chl-a	TSS
Input sites						
Wilsons River at South Lismore	X	X	X	X	X	X
Richmond River at Casino	X	X	X	X	X	X
Instream health sites						
Wilsons River at Whyrallah	X	X	X	X	X	X
Richmond River at Tatham	X	X	X	X	X	X
Wilsons River at Coraki	X	X	X	X	X	X
Richmond River at Coraki	X	X	X	X	X	X
Upper Richmond estuary at RR13	X	X	X	X	X	X

Appendix 3: Consultation Activities

This Appendix provides detailed information on the consultation activities undertaken during the preparation of the EPS (WBM, 2006), the Draft EMS and Draft CZMP

Richmond River Estuary Processes Study Discussion Paper

Introduction

The Richmond River Estuary is a highly valued natural resource for local inhabitants and tourists alike. The estuary supports a diverse range of human usage, of both a commercial and recreational nature, as well as supporting a variety of significant ecological communities. Recent investigations into the health of the estuary indicate that ecological communities supported by the estuary may be under stress from the types of human usage currently occurring on and around it.

Furthermore, the demands for living close to water are increasing Australia wide, and it is expected that there will be increases in the local population as a result of this demand. This is likely to lead to a corresponding increase in estuary usage, which if unmanaged, will exacerbate existing conflicts, cause additional habitat degradation, further reduce water quality levels, etc. In 1987, the NSW State Government introduced the *Estuary Management Policy*. One of the primary outcomes of the policy has been to introduce a process of addressing these issues before they became problematic.

For the Richmond River, this process commenced in 2000 with the formation of the Richmond River Estuary Management Committee. This Committee is responsible for the preparation of a series of key documents as outlined under the *Estuary Management Policy*. At the present time, the Committee is overseeing the preparation of an **Estuary Processes Study** (EPS) for the Richmond River Estuary. The EPS is primarily a technical study that will support the later preparation of an **Estuary Management Study and Plan**. WBM has been commissioned by the Richmond River County Council (which coordinates between the Ballina Shire Council, Lismore City Council and Richmond Valley Council) to prepare the EPS.

Purpose of the Discussion Paper

The EPS aims to develop the necessary scientific understanding of the estuary to enable informed decision making when the Estuary Management Study and Plan are commenced. To enable an initial prioritisation of key issues for the estuary and to assist us in understanding how it is currently used and valued by locals and tourists, this discussion paper has been prepared to obtain feedback from Estuary Management Committee Members.

In completing the discussion paper, it is important for Committee members to bear in mind that they are members of a group which represents the broader community. The discussion paper should take approximately 30 minutes to complete. When complete, please return (by mail or fax) your completed discussion paper no later than Friday 4th March 2005 to: Damion Cavanagh, WBM, PO Box 203, SPRING HILL QLD 4004, or fax 07 3832 6744. If you wish to speak to Damion he may be contacted on 07 3831 6744.

Please also note that when marking up the map provided, ensure that any marks/comments are referenced back to the questions in the discussion paper.

Executive Summary from the Data Compilation Study

WBM completed the Data Compilation Study (DCS) for the Richmond River estuary in 2004. The DCS aimed to guide and facilitate the efficient preparation of an Estuary Processes Study for the estuary, as well as provide a framework for the effective and efficient analysis of estuary processes.

The Principal conclusions and recommendations from the DCS as detailed in its Executive Summary are reiterated below:

- **Flooding and Tidal Hydraulics** – Following the review of hydrodynamic and hydrological processes, it is evident that considerable information, at various scales, has been gathered since the 1950's on the issue of flooding and flood mitigation. The ongoing work involving the Floodplain Management Studies from the affected local councils provide details on the current understanding, causes and management strategies. Further information is available in GIS format in terms of drainage and environmentally sensitive risk areas. Assessments of the extensive impacts caused by flooding in the region have been undertaken on social, financial and ecological grounds.

  Adequate sources have been identified in terms of hydraulic data as well as extensive recent flood studies. The review has also identified a number of calibrated hydrodynamic and flood models of the Richmond River. No additional data is required for an Estuary Processes Study (EPS) and it is recommended that the relevant Floodplain Management Studies be continued with implementation of the corresponding Floodplain Management Plans.

- **Water Quality** – Extensive monitoring data has been collected in terms of water quality. The principal conclusions from the studies are that water quality is poor when related to accepted guidelines and key indicators. Certain sources have also presented data that indicate a continuing decline in water quality in the estuary.

  The runoff from acid sulfate soils is attributed as being a significant cause of low pH and deficient dissolved oxygen levels periodically observed in the estuary. Intensive research has been exhibited as part of this review into the behaviour and impacts of acid sulfate soils. Nutrient over-enrichment from point and diffuse sources has also been identified, as has turbidity and sediment load issues attributed to diffuse catchment loads.

  Sufficient data has been identified to define the magnitude of point sources, such as the council sewage treatment works. Monitoring data and predictive capacities for diffuse catchment loads have also been researched. Data defining the point and diffuse loads within the estuary should therefore be collated from the variety of sources cited in this study. It is concluded that this data will be sufficient for the purposes of an EPS.

  It has been noted that the water quality data has in many cases not taken into consideration flow regimes, natural variability and the internal cycling of nutrients. It is recommended that the EPS collate and analyse all available data, and coordinate to collect any further required data to satisfy key spatial and temporal deficiencies. It is also recommended that the EPS incorporate investigations into key internal cycling processes, such as sediment fluxes, denitrification, etc.

Water quality modelling is recommended to improve system understanding and a predictive capacity for the Richmond River estuary. As previously mentioned, the review has also identified calibrated hydrodynamic models of the Richmond River.

- **Protection of Aquatic Habitat** – The aquatic biodiversity of the Richmond area has been the subject of many studies as evidenced in this report. The conclusions all indicate the same situation that the overall river health and extent/condition of aquatic habitat is in a poor state and in decline, river heritage is degraded and fish stocks are threatened. The "State of the Environment", NSW Fisheries and other ongoing government agency studies form a good source of information, with pressures such as the intensity of fishing, boating, erosion, barriers and the introduction of alien species having been identified.

  The EPS should collate and analyse all available data, and coordinate to collect further data to satisfy key spatial and temporal deficiencies. Continuation of a coordinated approach to ecological monitoring is also recommended.

- **Fishing and Fishery Management** – Numerous studies have been identified indicating that the impacts of recreational and commercial fishing are inherently linked to the state of the aquatic habitat and biodiversity generally. It is reported that in addition to natural pressures and effects, fishing, dependent on the intensity and type, can have substantial detrimental effects on fish stock and aquatic biodiversity. The stresses applied by the growing recreational fishing population, as well as the commercial fishing community, have been assessed by several sources.

  It is concluded that sufficient data exists for the purposes of an EPS. It is recommended that the EPS should correlate the existing data with that of water quality and aquatic habitat.

- **Fish Kills** – The available literature widely attributes the significant depletion of dissolved oxygen and the resulting fish kills that have occurred during major flooding to the runoff of acid sulfate soils. Intensive research has been exhibited into the behaviour and impacts of acid sulfate soils. An emerging issue related to acid sulfate soils in both coastal and inland areas is the presence of monosulfidic black oozes. These highly reactive sediments are often found in the drains in acid sulfate soil landscapes and can cause rapid and complete deoxygenation of waters when mobilised. They are considered to be a significant contributing factor in the deoxygenation of North Coast Rivers.

  An additional possible cause for the occurrence of deoxygenation and fish kills has been identified as increased oxygen demand from floodplain vegetation following flood events. A database of fish kills and investigations into the recovery of fish stocks has been established by NSW Fisheries.

  Research, management and guidelines relating to the general acid sulfate soil problem have been implemented. It is concluded that sufficient data exists for the purposes of an EPS and as with the fishery data, it is recommended that the EPS should correlate the existing data with water quality and aquatic habitat data.

- **Erosion and Riparian Vegetation** – Many sources have cited riverbank erosion as a major issue for the Richmond catchment. The principal causes are identified as the change of land use and the loss of riparian and other stabilising vegetation. Studies exist that map the condition and extent of riparian vegetation. Further mapping of active erosion zones is recommended, as data is deficient in this area. An assessment of the key erosional mechanisms involved should be

undertaken utilising the results of the survey, possibly supported by the interpretation of other modelling studies.

- **Shoaling, Navigation and Dredging** – A deficient amount of data has been found to be available in terms of these issues. Dredging ceased when the requirement for access to cane barges was removed and the subject is the focus of widespread concern with inconclusive studies that have examined the long-term trends in the spatial variation of sedimentation.

  Further research is therefore recommended, as there are differing accounts on the extent of the problem and the trends prior to and following dredging activities. The collation of dredging event data is recommended to provide an accurate picture of past activities. Additional bathymetric surveys, including the examination of historical survey sites, are also recommended to allow further comparison with historical data.

- **Water Extraction and River Flow** – The drought in 2003 brought this issue to the forefront and the need for long term planning to supply agricultural and urban requirements has been voiced. The extraction of river flows for irrigation and other demands is a significant concern for many licence holders. An initial investigation into the impacts of further extraction from and upstream of the tidal pool was undertaken in 1999.

  In light of the recent development of water quality and river flow objectives and changes in land use, such as subdivision, the increasing demand for water resources from the system has been acknowledged by several key sources. The variability of flow required for estuarine health is also a significant concern.

  Data is available concerning the number of licence holders and the rate of extraction from all areas of the Richmond River. Guidelines for river flow have also been established. Further investigations and modelling into the impacts of increased extraction for irrigation and domestic water supply purposes is recommended.

- **Waterway Usage –** Recognised as a priority issue in the lower estuary, the major concern is focussed on the lack of facilities and planning in relation to the use of the estuary as a functional port and for pursuits such as boating. Following the demise of the Ballina Quays Marina, the consultations indicate that the estuary has been left with deficient amenities, services and non-existent available moorings. The aspirations of interested parties display that there is great potential for the estuary in terms of tourism and the area's future development if facilities were provided.

  It is recommended that a suitable infrastructure/usage investigation be incorporated into the Environmental Management Study, potentially as a separate component e.g. waterway users management plan, and supported with a review of available data from the processes study.

QUESTION 1. RESPONDENT DETAILS

Name: ……

Occupation/Organisation: ……..

Month/Year of Joining Committee: ……...

QUESTION 2. ESTUARINE USAGE

Please list/describe below the top five uses of the estuary that you are aware of. **Please also mark the locations of these uses on the maps provided**. Recreational uses may include such activities as fishing (boat or shore), oystering, sailing, water-skiing, jet-skiing, prawning, swimming, surfing, canoeing, picnicking/walking on the banks, bird-watching, four-wheel driving, camping, snorkelling, spear fishing, crabbing, etc. Commercial uses may include such activities as fishing, prawning, oystering, etc.

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 3. ESTUARINE VALUES (FOR RESIDENTS)

Please list/describe below what you believe to be the five most valuable aspects of the Estuary. Aspects of value may include access to water, peace and tranquillity, water quality, recreational opportunities, commercial opportunities, natural surroundings, wildlife, natural beauty, views etc.

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 4. ESTUARINE VALUES (FOR TOURISTS)

What do you believe to be the five most valuable aspects of the estuary to tourists, e.g. open waterways for waterskiing, availability of fish to catch, clean water for swimming?

1. ……

2. ……

3. ……

4. ……

5. ……

How valuable is tourism to the region (very, moderate, not important)?

QUESTION 5. VISUAL AMENITY

Please describe any features located on or near the estuary of high visual quality, i.e. scenic locations, etc, that you consider to be valued by both by locals and visitors. **Please also mark the locations of these high visual quality areas on the maps provided.**

……..…

……..…

……..…

……..…

QUESTION 6. USAGE CONFLICTS

Are there any present conflicts in the use of the estuary that you are aware of e.g., boating noise impacts on residential areas, waterway usage impacts on banks or seagrass areas, boat usage impacts on safety, etc? **Please also mark the locations of any conflict zones on the maps provided**.

……..…

……..…

……..…

……..…

……..…

……..

QUESTION 7. ISSUES/THREATS

List the top five short and long-term threats you consider are facing the health of the estuary. Short term may be considered as five years, while long term may be considered as 20 years? Please note that a **healthy river** has been defined by the Healthy Rivers Commission as, "*a river whose condition, as indicated by a broad range of environmental, social and economic characteristics, enables it to support the natural ecosystems, commercial activities and social amenity desired by the community*."

Short-term threats/issues

1. ……

2. ……

3. ……

4. ……

5. ……

Long-term threats/issues

1. ……

2. ……

3. ……

4. ……

5. ……

QUESTION 8. QUALITY OF LIFE CONTRIBUTION

What contribution do you consider the estuary makes to the quality of life (High/Medium/Low contribution) of most individuals (in the study area)? A brief explanation of your answer would also be helpful.

……..…

……..…

……..…

……..…

……..…

……..

QUESTION 9. VISION FOR THE ESTUARY

What is your long-term vision for the estuary, i.e. estuary predominantly focused on catering to the needs of tourists, estuary remaining the same as it is now, estuary increasing its commercial usage, etc?

……..…

……..…

……..…

……..…

……..…

……..

QUESTION 10. BOATING/ESTUARY ACCESS

Please provide brief answers to the following questions specifically related to boating and access. Some of these questions may relate to those asked earlier, so please ignore this question if you have already addressed it.

Question 10.1

Please describe the principal boating types (e.g. boating for fishing, boating for skiing, commercial boating, etc) and the physical extent (please mark on maps provided) and estimated duration of boat usage undertaken in the estuary (i.e. 20 days per year). If you have addressed this in section 1.2, please ignore.

……..

……..

Question 10.2

What do you consider are the main social (e.g. relaxation), cultural (e.g. sporting) and economic benefits of boating to the region?

Social:

……..

Cultural:

……..

Economic:

…….

Question 10.3

Please describe the potential impacts of boating activities in relation to the social (i.e. noise issues, safety issues, etc) and environmental values (habitat preservation, bank stability, etc) of the estuary. If this question has been addressed in section 1.4 or 1.5 please ignore.

…….

…….

…….

…….

Question 10.4

Do you consider there to be potential for increased boating in the Richmond River estuary. If so, what form should this take and are there likely to be any impacts associated with the increased boating activity. If this question has been addressed in section 1.4 and 1.5, please ignore.

…….

…….

…….

…….

…….

…….

Question 10.5

Are there any impacts of shoaling on boating navigability? Do you think that this situation will change in the future?

…….

…….

…….

…….

…….

…….

Question 10.6

Are there any issues in relation to public foreshore access requirements? If so, where do you believe these issues exist (please mark on the map provided) and what may be done to resolve them.

…….

…….

…….

…….

…….

QUESTION 11. COMMUNITY AWARENESS

What do you believe to be the current overall level of community understanding of estuarine processes? What particular aspects of community understanding and awareness need to be improved to facilitate better estuarine management?

…….

…….

…….

…….

…….

RETURN DETAILS

Please return (by mail or fax) your completed discussion paper by **Friday 4th March 2005 to: Damion Cavanagh, WBM, PO Box 203, Spring Hill QLD 4004.** The discussion paper can be faxed to Damion on 07 3832 3627.

If you wish to know more about the study or wish to speak or meet with a study representative in person, please contact **Damion Cavanagh** on 07 3831 6744 or email him at dccavanagh@wbmpl.com.au.

Note: A series of maps of the catchment were provided at the rear of the Discussion Paper but have not been included here.

Appendix 1 – Community engagement, surveys, consultation and stakeholder workshops

Stakeholder engagement activities		
DATE	***TARGET***	***ACTIVITY***
29th 30th September	TARGETED ABORIGINAL ENGAGEMENT	Information stall and 37th Indigenous football knockout
27th October	TARGETED COMMUNITY	Surfrider foundation talk, surveys and clean up
15th November	STAKEHOLDER MEETING	Richmond River Estuary Management Committee
18th November	TARGETED COMMUNITY CONSULTATION	Rivafest stand surveys, exposure Ballina
29th November	ANNOUNCEMENT	Echo Eof I announcement
10th Dec	STAKEHOLDER MEETING	Floodplain committee meeting and presentation
11th Dec	STAKEHOLDER MEETING	Richmond River Estuary Management Committee meeting and presentation
12th December	BSC, LCC, RVC	LEP planning workshop
14th December	Community Engagement	Extension of EoI submission ABC Radio interview 97.9 FM interview Northern Star advertised announcement
24th December	Close of expressions of interest	Sort applications
29th Jan 2008	Community engagement gap analyses	Seek people to invite to fill gaps in community representation
5th Feb	Meeting with Tracey King NGULINGAH LOCAL ABORIGINAL LAND COUNCIL	Way Forward Aboriginal engagement
3-10th March	Liaise with RRCC	Development of presentation material
12th March	Richmond River Rescue Meeting	Attendance and Disuccion
17th March	FOCUS GROUP Lower catchment e.g. Ballina	Presentation surveys questions stakeholder list
19th March	FOCUS GROUP Upstream e.g. Lismore/Casino	Presentation surveys questions stakeholder list
26th March	Meeting with Estuary Management Committee	Presentation and update
April	ABORIGINAL ENGAGMENT	Letters to key Aboriginal stakeholders requesting engagement
22nd April	FOCUS GROUP FEEDBACK	Provided Draft outcomes to attendees of focus groups and other interested community members. Feedback requested
5th May	FOCUS GROUP FEEDBACK	Incorporated all feedback (6 responses) into the focus group outcomes and replied to emails.
16th May	ABORIGINAL ENGAGMENT	MEETING WITH BUNDJALUNG ELDERS
20th May	STAKEHOLDER ENGAGEMENT North Coast Weeds – Des Boorman	Discussing priorities for vegetation assessment relative to noxious and environmental weeds
25th June	STAKEHOLDER ENGAGEMENT Meeting with CMA –Nicole Strehling	Discussion of Catchment Action Plan and incorporating targets into the EMP
1st July	ABORIGINAL ENGAGEMENT	WORHSHOP WITH BUNDJALUNG ELDERS COUNCIL ABORIGINAL ELDERS CORPORATION
9th July	ABORIGINAL ENGAGEMENT	Follow up letter to Chairperson of Bundjalung Edlers

	Council Aboriginal Corporation and provision of additional information/ TBA
PUBLIC MEETING 2	Presentation of the Draft Study
PUBLIC MEETING 2	Presentation of Draft Plan

NOTES

- Richmond River Estuary Processes Study completed a community consultation phase (in total 3 survey forms were completed) although the lack of response was acknowledged no compensatory action was considered.

- The client is keen for all the community to know what an estuary is and the extent of the Richmond River Estuary

RICHMOND RIVER ESTUARY COMMUNITY SURVEY

PART A: Community Survey for developing an education program

Richmond River County Council together with the local councils of Lismore, Richmond Valley and Ballina is developing a community education program throughout the Richmond Valley. The program aims to:

a. enhance community understanding of key cause and effect relationships with respect to behaviours that are placing pressure on the ecological, social and economic values of the Richmond River, and

b. Identify, promote and encourage changes in community and government behaviour that aim to improve the health and long term sustainability of the Richmond River.

The first stage of the project is to undertake a survey of users of the Richmond River Estuary as well as the general community within the Richmond Valley.

The survey seeks to gather current information on how and where people use the estuary, what they see as the most important and special attributes of the estuary, and importantly what current and long term issues and threats the community considers the estuary to face. The survey also seeks information on the types of actions and strategies people wish to see to improve and protect the estuary into the future.

The results from the survey will be used by the Richmond River County Council to develop a range of education strategies and programs which will raise the community's and our visitors understanding of the environmental, social and economic significance of the estuary system and the ways in which we can collectively work towards the long term sustainability of the Richmond River.

Your participation in the survey is important and very much appreciated.

Estuary Definition

"an estuary is a partially enclosed coastal body of water ... part sea ... part waterway ... part land. They are places of transition from salt water to fresh water, from tidal to non-tidal and from wet to dry".

Estuaries come in all shapes and sizes and go by many different names. They are often called bays, lakes, lagoons, harbours, rivers or inlets. Estuaries provide a wide range of unique environments where conditions are constantly changing. They are completely transformed twice a day by the flood and ebb of the tide.

Sustainability Definition

Sustainability or ecologically sustainable development is a global approach to future development. It is a process of economic and social development that maintains a healthy functioning environment upon which all life depends

Ecologically sustainable development is based on a set of principles to achieve:

- long term economic viability;
- social harmony; and
- a healthy and attractive natural environment. (Northern Rivers Regional Strategy)

For the purpose of this consultation process estuary sustainability is considered to refer to the use, care and management of the estuary system so as to maintain the environmental, social and economic welfare of the system for future generations.

1. Survey Location	
Location:	Date:
2. Demographics	
Town of Residence:	
Age Group: 15-19 20-29 30-39 40+ Do you consider yourself part of a specific interest group (circle any that are relevant)? conservation indigenous tourism recreational fisher commercial fisher farmer local government other (please specify)_____	
3. Estuary Definition	
Please comment on what you understand to be the estuary; i.e how would you define the estuary?	
4. Usage	
a. Which location/s do you access and use the estuary and how do you use the estuary e.g. Wardell Boat Ramp/ launching boat; Pimlico Island/ fishing	
b. Approximately how many times per year do you use the Richmond River Estuary?	
c. What are the most frequent times of the year that you use the estuary?	
Summer Autumn Winter Spring All Year	

5. Special Attributes
Could you please identify the main features of the Richmond River Estuary that you consider to be the most important or special?
6. Current Estuary Issues
Could you please advise what you consider to be the main issues or threats currently facing the Richmond River Estuary?
7. Long Term Estuary Issues
Could you please advise what you consider to be the main issues or threats facing the long term sustainability of the Richmond River Estuary?
8. Issue Management
Could you please comment on what actions or strategies you would like to see undertaken to best address these issues?

9. Access to Information
Where do you most access information in relation to the current state of and issues relating to the Richmond River Estuary?
TV Newspaper Radio Internet . Brochures Other (please specify): _____
10. Further Information
Would you like further information and updates on the Richmond River Estuary and if so in what format?
Yes No TV Newspaper Radio Internet Brochures Delivered newsletter Other (please specify)_____
11. Current State of the Estuary
How would you rate the current state of the Richmond River Estuary?
Good (of a high standard with little or no improvement in quality required) Fair (acceptable quality but may/would benefit from improvement in quality) Poor (state affects but does not prohibit the range of current recreational uses and environmental attributes) Critical (State is not acceptable for current recreational and/or environmental quality)
12. Other Comments

Part B: Community Survey to determine environmental values

QUESTION 1

What level of protection and management intent do you think is suitable for the Richmond River Estuary? Note: Details as specified by the National Water Quality Management Strategy (NWQMS)

ENVIRONMENTAL VALUE	SUPPORTING DETAILS	TICK THE LEVEL YOU THINK IS APPRORIATE FOR RICHMOND RIVER
High conservation/ ecological value system (HCV)	These are systems that are largely unmodified or have undergone little change. They are often found in national park, conservation reserves or inaccessible locations. Targets for these systems aim to maintain no discernable change from this natural condition	
Slightly to moderately disturbed system (SMD)	These systems have undergone some changes but are not considered so degraded as to be highly disturbed. Aquatic biological diversity may have been affected to some degree but the natural communities are still largely intact and functioning. An increased level of change in physical, chemical and biological elements of these systems is to be expected.	
Highly disturbed systems (HD)	These are degraded systems likely to have lower levels of naturalness. These systems may still retain some ecological or conservation values that require protecting. Targets for these systems are likely to be less stringent and may be aimed at retaining a functional but highly modified ecosystem that supports other environmental values as assigned to it (e.g. primary industry)	

QUESTION 2

Please rate the following environmental values according to their relevance and level of importance to the Richmond River Estuary.

Environmental Value	Supporting detail	High	Medium	Low	Not Applicable
Aquatic ecosystems	**Habitat and wildlife in waterways and riparian areas**				
Primary Industries	**Irrigating** crops such as sugar cane, lucerne etc				
	Water for **farm use** such as fruit packing or milk sheds				
	Stock watering				
	Water for **aquaculture** such as oyster farming				
	Human consumption of wild or stocked fish or crustaceans				
Recreational & Aesthetic	**Primary recreation** with direct contact with water such as swimming or snorkelling				
	Secondary recreation with indirect contact with water such as boating, canoeing or sailing.				
	Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing				
Drinking water	**Raw drinking water** supplies				
Industrial uses	Water for **industrial use** such as power generation, manufacturing plants.				
Cultural & Spiritual	Cultural and spiritual values				

As specified in the National Water Quality Management Strategy (NWQMS)

Bottom of form

Town of Residence

Town	Number	Percent (%)
Ballina	15	51.7
Lismore	1	3.4
Lennox Head	10	34.5
Byron Bay	2	6.9
Wollongbah	1	3.4

Age Group

Age	Number	Percent (%)
15-19	2	7.1
20-29	2	7.1
30-39	7	25
40+	17	60.7

Interest Group

Group type	Number	Percent (%)
Conservation	14	38.9
Indigenous	1	2.8
Tourism	2	8.3
Recreational Fisher	11	30.5
Commercial Fisher	-	-
Farmer	2	5.5
Local Government	-	-
Boating	1	2.8
Surfer	2	5.5
Ecotourism	1	2.8
Scouts	1	2.8

Estuary Definition

Understand extent of Estuary?	Number	Percent (%)
Yes	10	37
No	17	63

Location of Use

Location of Use	Number	Percent (%)
Boat ramps	8	19.5
Boat docks	1	2.4
Break walls	1	2.4
Parks & walkways	6	14.6
Beaches / banks	3	7.3
Public Access points	4	9.8
Open water	3	7.3
Quays	1	2.4
Mobbs Bay	1	2.4
Shaws Bay	1	2.4

North Creek	1	2.4
Broadwater	2	4.9
Wardell	1	2.4
Lismore	1	2.4
Ballina	3	7.3
All	4	9.8

Frequency of Use

Frequency	Number	Percent (%)
Daily	12	42.9
Weekly	7	25
Fortnightly	3	10.7
Monthly	1	3.6
Yearly	5	17.9

Timing of Use

Timing	Number	Percent (%)
Summer	8	23.5
Autumn	2	5.9
Winter	-	-
Spring	4	11.8
All year	20	58.8

Estuary Issues (given in total respondent numbers)

Issues	Current	Long - Term	Management
Agricultural Practices	9	7	7
Urban Developments	7	9	4
Loss & poor condition of riparian veg	-	-	2
Declining fish stocks	8	6	3
Obstructions to fish migration	-	-	-
Ballina STP discharge	2	-	2
Poor water quality (black and acid water)	14	9	1
Boating facilities not suitable	9	1	3
Climate change	-	2	-
Silting / infilling	6	5	3
Stormwater	2	1	1
Education / awareness	-	-	8
Rubbish	3	1	5
Non-compliance with rec fishing laws	1	1	-
Lack of fishing regulation enforcement	-	-	3
Community involvement	-	-	2
Wetland restoration	-	-	2
Aquatic weeds	1	-	
Erosion	3	-	1
Loss of wildlife	1	1	-
Boating pressure	2	1	1
No appreciation by authorities	1	1	-
Money	1		1

Nutrients	1	1	

Access to Information

Access Type	Number	Percent (%)
TV	7	12.9
Newspaper	21	38.9
Radio	7	12.9
Internet	8	14.8
Brochures	8	14.8
Rous Water	1	1.9
Direct Inquiry	1	1.9
Visual inspection	1	1.9

Further Information

Want further Info	Number	Percent (%)
Yes	22	88
No	3	12

Further Information Type

Access Type	Number	Percent (%)
TV	6	14.6
Newspaper	12	29.3
Radio	6	14.6
Internet	5	12.2
Brochures	5	12.2
Delivered newsletter	6	14.6
Schools	1	2.4

Perceived state of the Estuary

Perceived State	Number	Percent (%)
Good	3	10.3
Fair	16	55.2
Poor	10	34.5
Critical	-	-

- Tweed River Floodplain Management could be useful for Richmond River
- Community should be informed of pollutant levels and management undertaken
- River health is OK in fine weather. The problem is when it rains
- We need exciting, interactive education involving Aboriginal people and culture
- Oysters for eating are a good benchmark for water quality targets
- Need a full time fisheries enforcement officer
- Excellent resource that deserves serious management for future users
- Carefully planned rock walls provide excellent hatcheries for fish stocks
- Need a dedicated “River Council” which controls how the estuary is used. Coordinate with Fisheries

- Need shock tactics for the public so they understand the issues
- Survey people who live directly on the estuary. See what they see
- Harvest the estuary to create energy
- Eat stocked fish, not wild resources

Table : Results of public survey

QUESTION ONE: WHAT LEVEL OF PROTECTION & MANAGEMENT DO YOU THINK IS SUITABLE FOR THE RICHMOND RIVER?		
	Number of Respondents	Percent %
HIGH CONSERVATION	11	44
SLIGHT TO MODERATELY DISTURBED	13	52
HIGHLY DISTURBED	1	4
Total	25	100

Public Rating of Environmental Values (Given total respondent numbers)

PUBLIC COMMENTS	**High**	**Medium**	**Low**	**N/A**
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	26	1	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	6	10	10	2
Water for farm use such as fruit packing or milk sheds	5	12	10	2
Stock watering	6	12	7	1
Water for aquaculture such as oyster farming	14	11	2	-
Human consumption of wild or stocked fish or crustaceans	16	8	2	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	18	7	4	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	15	8	5	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	19	7	3	-
DRINKING WATER				
Raw drinking water supplies	13	7	6	2
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	5	10	12	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	17	9	2	-

Public Rating of Environmental Values (Given as % by column)

PUBLIC COMMENTS	High	Medium	Low	N/A
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	16.3	0.9	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	3.8	9.8	16.4	28.6
Water for farm use such as fruit packing or milk sheds	3.1	11.7	16.4	28.6
Stock watering	3.8	11.7	11.5	14.3
Water for aquaculture such as oyster farming	8.9	10.8	3.3	-
Human consumption of wild or stocked fish or crustaceans	10	7.8	3.3	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	11.3	6.9	6.6	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	9.4	7.8	8.2	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	11.9	6.9	3.3	-
DRINKING WATER				
Raw drinking water supplies	8.1	6.9	9.8	28.6
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	3.1	9.8	19.7	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	10.6	8.8	3.3	-

Public Rating of Environmental Values (Given as % by row)

PUBLIC COMMENTS	High	Medium	Low	N/A
AQUATIC ECOSYSTEM VALUES				
Habitat & wildlife in waterways and riparian areas	96.3	3.7	-	-
PRIMARY INDUSTRIES				
Irrigating crops such as sugar cane, lucerine etc.	21.4	35.7	35.7	7.1
Water for farm use such as fruit packing or milk sheds	17.2	41.4	34.5	6.9
Stock watering	23.1	46.2	26.9	3.8
Water for aquaculture such as oyster farming	51.9	40.7	7.4	-
Human consumption of wild or stocked fish or crustaceans	61.5	30.8	7.7	-
RECREATIONAL & AESTHETIC				
Primary recreation with direct contact with water such as swimming or snorkelling	62.1	24.1	13.8	-
Secondary recreation with indirect contact with water such as boating, canoeing or sailing	53.6	28.6	17.9	-
Visual appreciation with no contact with water such as picnicking, bushwalking, sightseeing	65.5	24.1	10.3	-
DRINKING WATER				
Raw drinking water supplies	46.4	25.0	21.4	7.1
INDUSTRIAL USES				
Water for industrial use such as power generation, manufacturing plants	18.5	37.0	44.4	-
CULTURAL & SPIRITUAL				
Cultural and spiritual values	60.7	32.1	7.1	-

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RICHMOND RIVER ESTUARY FOCUS GROUP MEETING FOR THE RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND PLAN

17th March 2008 **Ballina Beach Resort**

ATTENDEES: Garry Owers, Ken and Sue Thurlow, Nadia Elliot-Burgess, Ken Clarke, Sergio Jacomy, Ian McCabe, Serge Killingbeck, Ellen White, Lee Andresen.

Amanda Reichelt-Brushett (Australian Wetlands) Ken McLeod (Ethos Foundation) Facilitator

RANKED IMPORTANCE OF ESTUARY VALUES TO THE COMMUNITY ESTUARY FOCUS GROUP

Attendees were asked to consider a list of estuary values, add to that list any estuary values that were deemed missing, and then through a multi-vote system rank the values in order of importance. The information below is a summary of the outcomes from the ranking assessment.

SOCIAL VALUES

*Intergenerational equity
*Education potential
*Recreational fishing
*Ocean access
*Foreshore access
*Swimming/snorkelling
*Boating
*Recreational Use of Foreshore
*Spiritual values

AESTHETIC VALUES

*Aquatic flora and fauna
*Ambience/experience of the environment
*Clean beaches and foreshores
*Scenic amenity/view
*Terrestrial flora and fauna

Highest Importance
Highly Important
Very Important
Important

ECONOMIC VALUES

*Economic health in general
*Fishing industry
*Farming lands
*Nature based activities
*River related industry
*Restoration and rehabilitation values
*Marketing
*Tourism
*Education resource
*Real estate values linked to river health

ECOLOGICAL VALUES

***Healthy Water Quality**
*Riparian Zone Integrity –corridor connectivity and vegetation
*Biodiversity
*Aquatic flora and fauna
*Floodplain revegetation
*Integrity of wetland species
*Threatened species/communities
*Wildlife corridors
*SEPP 14 wetlands
*Intertidal Shoals
*Nursery ground for fish

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COMMUNITY ESTUARY FOCUS GROUP FEEDBACK ON ESTUARY ISSUES

The focus group discussed the issues presented in the Estuary Processes Study, made recommendations to add issues and then broke off into 4 small working groups. Each working group were given 2-4 of the established issues to discuss and consider on new issues identified in earlier discussion. Some groups chose to

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
DEVELOPMENT	land use mapping 10 years old	
	lack of estuary protection through Local Environmental Plans	
	urban development and infrastructure impacts	The impact of river heath will also affect real estate values
	dredging impacts and needs	
	flooding	
WATER QUALITY	sewer overflows and effluent e.g. North Creek	
	sediment and nutrient loads in catchment runoff	PRIORITY A within water quality-Sampling of sediment and biota including heavy metals, and other chemicals, fertilizers, pesticides. Toxicology sampling (independently verified) - ongoing
	quality -dredging in upper estuary impacting on turbidity levels	Marginal impact of existing facility
	management of floodplain areas (ASS and black water)	
	high flow pulses	
	faecal coliforms	
	monitoring approach and understanding	PRIORITY B within water quality. All data should be made available to the public. Need a catchment wide monitoring approach. Need benchmarks to assess condition -helps public understand improvement or decline. Need to define how to fund improvement works.
	stormwater	
	Impact from river bank erosion from stock access	
ECOSYSTEM AND BIODIVERSITY	poor water quality impinging on aquatic ecosystem health and function	
	loss of and damage to riparian vegetation	
	limited protection of sensitive ecological communities in the estuary e.g. seagrass and saltmarsh	
	poor condition of riparian vegetation	
	loss and degradation of key wetlands	

	on floodplain and important terrestrial habitats	
	fish stocks	
	fish migration	
	protection of high conservation value remnants of private land	
		Documented database required. Should include: Chemical usage within catchment, historical / present from urban / agricultural / industrial Extractive industries impact (dredging etc)

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CULTURAL VALUES	Incomplete cultural heritage studies	
	Timely adoption of cultural heritage sites and artefacts int the appropriate registers to ensure long term preservation.	
	Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works)	
	Limited knowledge transfer of Richmond River Estuary pre and post European history	
EDUCATION	poor understanding of fishing impacts on fisheries health and controls	
	estuary ecology	
	Programs and actions for estuary health and improvement	Use organisations such as Australian Seabird Rescue
		Educating public on needs and impacts of aquaculture
		How to bring about change - community actions - publicity - education
PUBLIC ACCESS AND RECREATIONAL AMMENITY	waterfront structures and licensing	Important: Marina – Ballina, Wharves / Jetty, Swing moorings
	lack of suitability of boating facilities	lack of solution to lack of boating facilities
	need for recreational boating plan	Implementation of plans that are there
	navigation improvement and information transfer	Upgrade of and holistic planning for markers Dredging of bar and river

	lack of knowledge in terms of conflict between users	Relates to infrastructure, Lack of facilities (LGA knowledge)
	concentration of boating activities in the lower estuary, lack of facilities for small vessels e.g. kayaks.	
		Poor public access to foreshore, Need to go thru private land to get to public / crown land
		Local regulation "man on the ground"
RESEARCH	Factors affecting health	
	Information sharing and accessibility is limited	
		PRIORITY B within research Factors affecting health of river (prioritising)
		How to effectively implement remediation and rehabilitation measures
		PRIOITY A within water qulaity Using body of available knowledge

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ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CLIMATE CHANGE	understand threats	
	implementing adaptive actions	
		Major mapping with coordination of Authorities and public – public needs access to metadata
		Effects on coastal transport (nearby roads), infrastructure, sewage etc.
		Need to relocate food supplies – more adaptable to change, less dependant on fixed structures
		Water level effects on contaminated sites: landfill / sewage etc.
		Health – eg. Vector / water borne diseases
		Development impacts of engineered solutions on other areas – impacts downstream - economic and social impacts particularly on urban development in low lying areas
ECONOMIC	Promotion and support of economically and environmentally sustainable agriculture industries (and practices) within the region and study area.	
	Promotion and support of economically and environmentally sustainable tourism within the region and study area.	
		Richmond River is important to ALL business and industry
AQUACULTURE	presence of QX disease and lack of understanding	
	loss of North Creek harvest area.	
	water quality concerns	-public -industry

ADDITIONAL ISSUES IDENTIFIED IN THE COMMUNITY FOLCUS GROUP		
GOVERNANCE	GROUP 1	• It is impossible, in an environment starved for somewhere to moor a boat, to retain or secure mooring points. Administrative restraints are restrictive, out of date and the lack of focus on the objective, rather than process. Waterways in transition – not being able to respond – 'no man on the ground' • The ability to respond immediately is paramount • Higher degrees of discretion and flexibility are required. Management from Macquarie St doesn't work • Respond to Lower RR Recreational Boating Study. What happened to the action items. Where are the outcomes? ACTION – ACCOUNTABILITY • Plying limits – need revisiting and should not be administrative decision – again 'man on the ground' • Keeping regulations up to speed. This relates only to HIRE and drive
	GROUP 2	• Regulation in terms of predicted climate change impacts • Peak oil – economic effect • Integrated mapping / research initiatives between all levels of government and with public participation and access to outcomes • Future amalgamations – catchment integration, rather than fragmentation – ecological values to be an integral component of amalgamation decisions. Even without amalgamation, shires to cooperate within catchment boundaries. • **At local, state and federal government level fragmentation of mapping layers to be addressed and made freely available to public (priority)** • Governance by private rural landowners: buy backs? education? regulation? attractive covenants and stewardships?
	GROUP 3	• non compliance • lack of enforcement • lack of clarity (confusion) of roles and responsibilities of Government and Non Government agencies (**B**) • Competition between agencies (**B)** • Meaningful and useful performance targets for responsible agencies • Identification of sole authority to manage and regulate all agencies (eg. Northern Rivers Catchment Authority) (**A**) • OR separate body for management and regulation of all aspects
	GROUP 4	• no promotion or support across industry • no budget • no capacity to action • LGA has no teeth • No differential rating structure like other LGA's • Less effective Economic Development Unit due to funding and resource • Less effective Chamber of Commerce • NSW Maritime Control mooring systems. No mooring which results in anchors straight into seagrass beds eg. Mobbs Bay (due to litigation fears)

Australian Wetlands

RICHMOND RIVER CATCHMENT FOCUS GROUP MEETING FOR THE RICHMOND RIVER ESTUARY MANAGEMENT STUDY AND PLAN

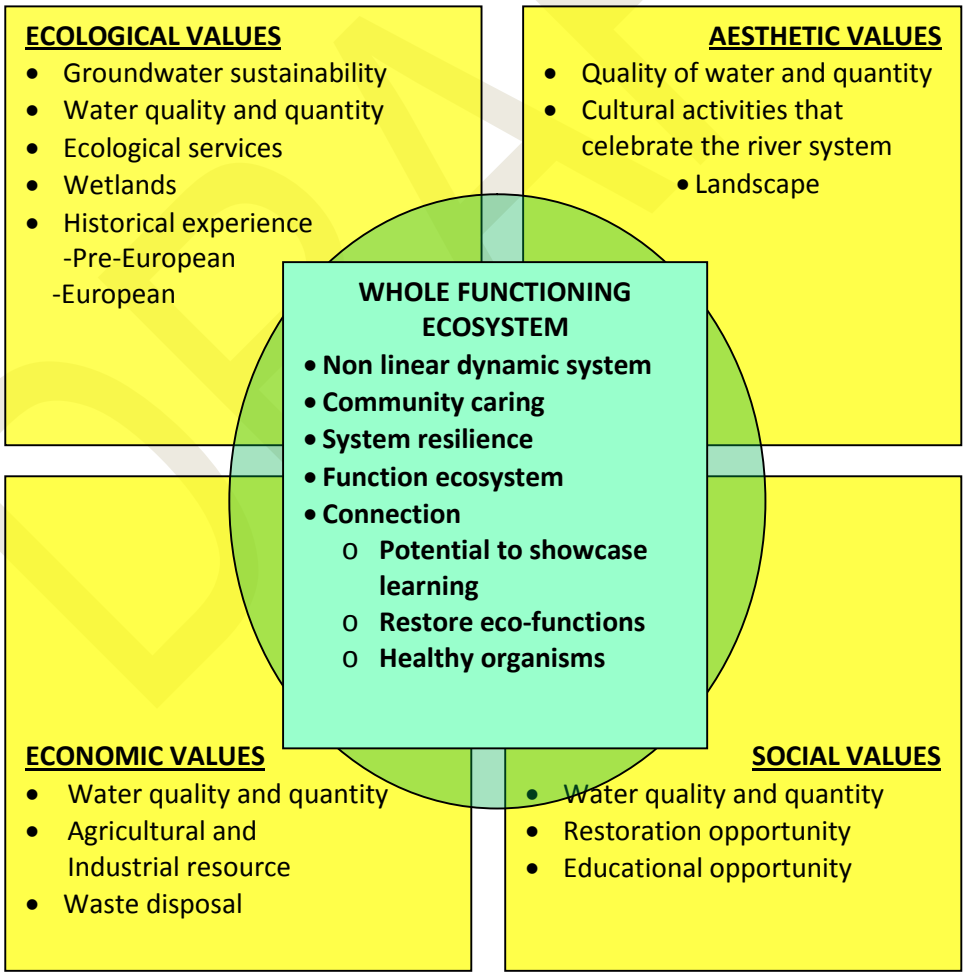
19th March 2008 **Lismore Workers Club**

ATTENDEES: Paul Weir, George Henderson, Eshana Bragg, David Pont, Daniel Clegg, Lynne Deweaver, Richard Gates, Simon Clough, Kristen Den Exter, Malcolm Johnson, Trevor Roberts, Maree Thompson, Emma Sweeny, Renee Silvester, Emma Murray, Bearnie Childs, Tom Amey.

Amanda Reichelt-Brushett (Australian Wetlands) Ken McLeod (Ethos Foundation) Facilitator

RANKED IMPORTANCE OF ESTUARY VALUES TO THE COMMUNITY CATCHMENT FOCUS GROUP

Attendees were asked to consider a list of estuary values, add to that list any estuary values that were deemed missing, and then through a multi-vote system rank the values in order of importance. The group as a whole preferred to focus on the integration of the values and open discussion led to producing the following holist valuing of the estuary.



COMMUNITY CATCHMENT FOCUS GROUP FEEDBACK ON ESTUARY ISSUES

The focus group discussed the issues presented in the Estuary Processes Study, made recommendations to add issues and then broke off into 4 small working groups. Each working group were given 2-4 of the established issues to discuss and consider new issues identified in earlier discussion. Some groups chose to prioritise sub issues presented in each issue.

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
DEVELOPMENT	land use mapping 10 years old	
	lack of estuary protection through Local Environmental Plans	
	urban d'ment & infrastructure impacts	Consider waterless sewage systems
	dredging impacts and needs	
	floodplain	Return areas to wetland
		Population increase
		Humans need to take responsibility for all of their waste products
		Protection of important habitats
		Protection of high quality agricultural land
WATER QUALITY	sewer overflows and effluent e.g. North Creek	Eliminate overflows
	sediment and nutrient loads in catchment runoff	Reduce sediment runoff from farms and revegetate riparian zones
	quality -dredging in upper estuary impacting on turbidity levels	No dredging
	management of floodplain areas (ASS and black water)	More resources and more controls –investigate potential for carbon sink
	high flow pulses	Use floodplain to manage floods
	faecal coliforms	
	monitoring approach and understanding	More resources to increase community awareness of river science
	stormwater	Each LGA should develop stormwater DCPs
	Impact from river bank erosion from stock access	Off stream watering point should be a requirement
ECOSYSTEM AND BIODIVERSITY	poor water quality impinging on aquatic ecosystem health & function	
	loss of and damage to riparian vegetation	
	limited protection of sensitive ecological communities in the estuary e.g. seagrass and saltmarsh	
	poor condition of riparian vegetation	
	loss & degradation of key wetlands on floodplain & imp. terrestrial habitat	
	fish stocks	What are the impacts of trawling practices
	fish migration	
	protection of high conservation value remnants of private land	
		Integrated monitoring systems
		Access to planning and resources to best practice riparian restoration (advice training, education, skills in on-ground work)

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CULTURAL VALUES	Incomplete cultural heritage studies	Use Bundjalung mapping program as a model
	Timely adoption of cultural heritage sites and artefacts int the appropriate registers to ensure long term preservation.	
	Protection of cultural and heritage items and sites from future activities (e.g. land clearing or foreshore works)	Sites should include 'landscapes'
	Limited knowledge transfer of Richmond River Estuary pre and post European history	
		Link with education on all levels primary, secondary and tertiary. Importance of school curricula and links to community (e.g. clean up days, litter surveys)
		Need to link cultural values to economic values
EDUCATION	poor understanding of fishing impacts on fisheries health and controls	
	estuary ecology	Education is required to understand how easily it can be impacted by poor landuse practices
	Programs and actions for estuary health and improvement	Estuary limit is Boatharbour, not Lismore or Lagoon Grass.
		Get all the public passionate about river quality
		Schools should use the river focus to engage in programs through environment groups, agriculture groups, sporting activities.
PUBLIC ACCESS AND RECREATIONAL AMMENITY	waterfront structures and licensing	
	lack of suitability of boating facilities	
	need for recreational boating plan	The boating plans need to address river bank erosion from power boats.
	navigation improvement and information transfer	
	lack of knowledge in terms of conflict between users	Kayaks and power boats usage needs clash
	concentration of boating activities in the lower estuary, lack of facilities for small vessels e.g. kayaks.	
RESEARCH	Factors affecting health	
	Information sharing and accessibility is limited	Information on monitoring needs to be reported back to the commmunity
		Need good monitoring to obtain ongoing database

ISSUES IDENTIFIED IN THE RICHMOND RIVER ESTUARY PROCESSES STUDY		COMMUNITY COMMENTS AND FEEDBACK
CLIMATE CHANGE	understand threats	
	implementing adaptive actions	
		Explore carbon credits for revegetation of riparian zone and cattle paddocks
		Urgently need to understand the consequences of change including: Rainfall frequency and intensity Tolerance of species Determine species with tollerance
		Future planning must include climate change
		How does climate change influence the changing runoff from the Pacific Highway upgrade
		Individuals can be proactive
ECONOMIC	Promotion and support of economically and environmentally sustainable agriculture industries (and practices) within the region and study area.	Develop new opportunities for more sustainable industries. Sustainability need to be considered in terms of the role of the River as **source, sink and amenity**.
	Promotion and support of economically and environmentally sustainable tourism within the region and study area.	
		Consider carbon credit market
		Need to speak the economic language to influence decision making
		Ecosystem goods and services need to be factored in as real costs and benefits
		Footprint and lifecycle analyses of industries
AQUACULTURE	presence of QX disease and lack of understanding	
	loss of North Creek harvest area.	
	water quality concerns	

ADDITIONAL ISSUES IDENTIFIED IN THE COMMUNITY FOCUS GROUP					
GOVERNANCE	GROUP 1	GROUP 2	GROUP 3	GROUP 4	GROUP 5
Local government decisions are unpredictable/poor, lack of resources, high expectations,	∃	∃	∃		
LEPs could provide more leadership for issues affecting river health		∃			
Estuary over three local government areas (Catchment 5 LGAs)	∃				
Three levels of government have different rules that often conflict/ Duplication and fragmentation of plans and policies (in and between tiers of government) etc	∃		∃		
The whole of catchment approach should be taken into account for accessing information and research. Issues should not be looked at in isolation.	∃	∃			
Funding is lacking rate base is low compared to Gold Coast	∃				
Individuals and groups are driving the initiative for actions, governance should support this.	∃				
Government departments are out of touch with the locality and issues		∃			
Local government should develop partnerships with agriculture industry and community working groups. Would promote stewardship of river system on public and private land.		∃	∃		
Governments should treat the River health as essential infrastructure		∃			
Funding from existing and new sources needs to be channelled to management authority with long term model for change		∃	∃		
A bi-partisan/across shire "accord" for river management is required (or amalgamate)			∃		
Knowledge, values and issues need to be addressed in an integrated planning framework for effective funding and implementation of restoration,				∃	
Administrative restraints are restrictive, out of data and lack focus on current day objectives.					∃
Management should be interactive and resources need to be available for immediate responses to management needs					∃
Lower Richmond River Boating Policy is not active, who is accountable? Man on the ground required					∃
LAND USE					
Best practice agriculture (including aquaculture). Consideration to affects of land practices on health of catchment and estuary.	∃				
Community awareness of landuse is required	∃				
Sewage systems are inadequate	∃				
Monitoring systems need objective measures of thea level of impact of an activity on water quality (e.g. development)	∃				
Lack of awareness upstream of the effects downstream, lower river, estuary and ocean. (E.g. soil loss from macadamia farms)	∃				

MANAGEMENT PRIORITY FOR INDIVIDALS

At the end of the focus group session each participant (15 in total) was asked to name their highest management priority.

Participant	Management Priority
1	Co-ordinated approach to a whole of system management that is adequately resourced.
2	A Richmond Valley Alliance with resources and power needs to be established so one authority has the task of managing river health
3	Language of community engagement and how we get stakeholders. "What's in it for me"
4	**As for 1** and the people involved need to know what they are doing.
5	**As for 1** and sufficient public awareness, passion and commitment is required to make it work.
6	Community to take responsibility and the management systems should be participatory as possible
7	**As for 1 and 2** and should be driven by community (recommend a independent statutory mandate)
8	**As for 1**
9	Sustainable improvement with a balances approach
10	**As for 1 and 2** and with community support and 'teeth'.
11	Education and engagement of general community
12	Public awareness and positive timely opportunity to do it well (improve river) positive attitude.
13	Do it don't just talk about it
14	**As for 1**
15	**As for 2** Single management authority a good idea. Need to focus on the task. Business as usual is not an option
16	Priority Setting should be criteria based and criteria should be outcome based. Define desired outcomes from the effort and the criteria that determines those outcomes.

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Appendix 4: Options Assessment

This Appendix provides detailed information on the assessment of management options including methodology and results

1. OPTIONS ASSESSMENT

The evaluation of potential management options is critical to the development of the management strategies. This has been undertaken as follows:

- The individual management options have been assigned an “Option Benefit Score”; and
- The total option scores for each category of option have been visually compared with the associated issue priority.

1.1 Ranking of Issues

A list of key issues was compiled from concerns raised by the scientific assessment (WBM, 2006; ABER, 2007; ABER, 2008), the general community and stakeholder groups. Key issues were grouped in terms of their overall impact and discussed in terms of major contributing factors.

All issues were ranked to focus management effort on those issues regarded as a priority in achieving the objectives of the plan. Issues were ranked with reference to:

- The importance of the issue in relation to the underlying ecological functioning of the river;
- The community perception of the issue;
- The degree to which the issue contributes to other issues in the estuary;
- The geographic extent and frequency of the issue; and
- The potential for the issue to have significant economic implications for the community - economic Implication scores were determined by a further break down and scoring according to the main economic sectors of the local area.

The issue ranking process and results are shown in Tables A1 and A2.

1.2 Option Benefit Score

Within the detailed descriptions of each management option, the social, environmental and financial considerations have been identified. The focus is on achievement of the key objectives, multiple issues and identification of high-value solutions.

The options assessment considered:

- Achievement of management objectives – achievement of the objectives is the primary goal;
- Social, environmental and economic consequences (of implementing as well as not implementing the option);
- Expected community and agency support; and
- 10 year implementation costs.

The options assessment process considered:

- The degree to which the option addresses the objectives – either directly contributes, indirectly contributes or conflicts with the objectives (Management Objective Score);
- The “Benefit” score – based on the likelihood of successful implementation and agency acceptability and likelihood of positive changes for the estuary (i.e. a combination of the consequences and the level of support); and

- The “Cost” score – classified as very high, high, medium or low based on capital and 10 year recurrent costs.

The overall Benefit/Cost score was derived by:

$$Option\ Benefit\ Score = \frac{Management\ Objective\ Score\ \ x\ \ Benefit\ Score}{Cost\ Score}$$

The Management Objective Score, Benefit and Cost Scores and overall Option Benefit Scores are provided in Tables A3, A4 and A5.

1.3 Comparison with Issue Priority

As each management option addresses a given issue or series of issues, it is possible to visualise the overall attractiveness of each option against the priority of the issue(s) addressed. Visualisation in this way provides additional information and management guidance that is not obvious when considering score matrices. This demonstrates the importance of considering issue priority as well as the ability of the options to address issues (i.e. another dimension to the decision making process).

The attached Table A6 shows the relationship between the issues and the options that address them. The Issues Score for each option is determined from the issues that the option addresses (weighted by the rank of the issues).

As part of the shortlisting process, a sensitivity analysis was also undertaken including potential climate change scenarios, conflicting priorities, data gaps and confidence in the scientific basis and/or expected outcomes of the options.

The attached Figure A1 compares the Option Benefit Score with the Issues Score for each individual option.

1.4 Strategy Evaluation

The options considered in this study have been identified for a range of purposes e.g. studies that are required to further refine or prioritise management actions, options that are complementary i.e. they achieve a similar outcome but are applicable to different geographical areas and/or issues, and options that are mutually exclusive in that only one of the options is appropriate. Because of this, the assessment of individual options shown in Figure A1 does not provide a full representation of the required management effort. To address this, the options have been assessed as bundles applicable to each issue category.

Figure A2 compares the Average Option Benefit Scores and the Total Issues Scores for each category of issues (Strategy). Based on the priorities displayed here, the management strategies will be developed as part of the Coastal Zone Management Plan.

Table A1: Ranking of Issues

Category	No.	Issue	Effect on Estuary Function	Community Perception	Cause of Other Issues	Geographic Extent	Issue Frequency	Economic Implications	Issue Score	Issue Rank
			[0-5]	[0-5]	[0-5]	[0-5]	[0-5]	[0-5]	[0-30]	
Administration and Governance	I1	Lack of protection to estuaries through existing planning instruments.	Pre- requisite						25	
Administration and Governance	I2	Lack of good governance model for integrated decision making and coordination	Pre- requisite						25	
Monitoring and Evaluation	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	Pre- requisite						25	
Administration and Governance	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	Pre- requisite						25	
Riparian Zone Management and Erosion	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	3	4	3	5	5	2	22	2
Riparian Zone Management and Erosion	I6	Unrestricted stock access causes vegetation damage and bank erosion.	3	2	2	2	3	1	13	10
Riparian Zone Management and Erosion	I7	Lack of incentive for landholders to address bank erosion	3	2	3	3	3	1	15	8
Waterway Usage	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	1	1	2	1	1	2	8	20
Waterway Usage	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	1	2	1	2	2	1	9	17
Floodplain Infrastructure Management	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	5	5	3	3	3	1	20	4
Floodplain Infrastructure Management	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	5	5	3	4	2	1	20	4
Farm Management	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	5	5	4	4	5	2	25	1
Urban Runoff	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	2	2	1	1	1	0	7	21
Wastewater	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	2	4	1	1	2	0	10	15
Wastewater	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	1	2	1	1	1	1	7	21
Monitoring and Evaluation	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	3	4	1	2	1	1	12	11
Riparian Zone Management and Erosion	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	3	3	3	5	5	1	20	4
Floodplain Infrastructure Management	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	4	4	4	4	4	1	21	3
Floodplain Infrastructure Management	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	5	3	4	5	2	0	19	7
Administration and Governance	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	2	3	2	3	0	0	10	15
Riparian Zone Management and Erosion	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	1	2	1	3	2	0	9	17
Vegetation Management	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	1	2	3	3	2	1	12	11
Waterway Usage	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	2	2	1	2	2	0	9	17
Fishery Management	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	0	3	1	2	1	0	7	21
Fishery Management	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	1	2	0	1	2	1	7	21
Fishery Management	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	1	2	1	1	2	0	7	21
Waterway Usage	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	0	2	0	1	0	1	4	29
Waterway Usage	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	0	3	1	1	1	0	6	26
Waterway Usage	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	0	1	1	1	1	0	4	29
Waterway Usage	I30	Siltation is affecting navigation and/or safety in the lower river	0	5	0	0	0	1	6	26
Waterway Usage	I31	Lack of provision of appropriate public access to foreshore	0	5	2	3	3	1	14	9
Cultural Heritage	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	0	3	0	1	1	1	6	26
Climate Change Adaptation	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological communities and bank erosion	2	2	4	3	0	1	12	11
Climate Change Adaptation	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	2	2	4	3	0	1	12	11

Table A2: Economic Implications of Issues

Category	No.	Issue	Economic implications for sector			Total Score	Average Score
			Tourism	Fishing	Agriculture		
			[0-5]	[0-5]	[0-5]	[0-15]	(0-5)
Administration and Governance	I1	Lack of protection to estuaries through existing planning instruments.	0	0	0	0	**0**
Administration and Governance	I2	Lack of good governance model for integrated decision making and coordination	0	0	0	0	**0**
Monitoring and Evaluation	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	0	0	0	0	**0**
Administration and Governance	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	0	0	0	0	**0**
Riparian Zone Management and Erosion	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	2	3	1	6	**2**
Riparian Zone Management and Erosion	I6	Unrestricted stock access causes vegetation damage and bank erosion.	1	2	1	4	**1**
Riparian Zone Management and Erosion	I7	Lack of incentive for landholders to address bank erosion	1	2	1	4	**1**
Waterway Usage	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	2	3	0	5	**2**
Waterway Usage	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	1	1	0	2	**1**
Floodplain Infrastructure Management	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	1	2	0	3	**1**
Floodplain Infrastructure Management	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	1	2	0	3	**1**
Farm Management	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	3	3	0	6	**2**
Urban Runoff	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	1	0		1	**0**
Wastewater	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	1	0	0	1	**0**
Wastewater	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	1	1	0	2	**1**
Monitoring and Evaluation	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	1	1	0	2	**1**
Riparian Zone Management and Erosion	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	1	1	0	2	**1**
Floodplain Infrastructure Management	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	1	1	2	4	**1**
Floodplain Infrastructure Management	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	1	0	0	1	**0**
Administration and Governance	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	0	0	0	0	**0**
Riparian Zone Management and Erosion	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	0	0	0	0	**0**
Vegetation Management	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	2	2	0	4	**1**
Waterway Usage	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	0	0	0	0	**0**
Fishery Management	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	0	0	0	0	**0**
Fishery Management	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	1	1	0	2	**1**
Fishery Management	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	0	1	0	1	**0**
Waterway Usage	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	1	1	0	2	**1**
Waterway Usage	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	0	0	0	0	**0**
Waterway Usage	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	0	0	0	0	**0**
Waterway Usage	I30	Siltation is affecting navigation and/or safety in the lower river	2	1	0	3	**1**
Waterway Usage	I31	Lack of provision of appropriate public access to foreshore	2	2	0	4	**1**
Cultural Heritage	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	1	1	0	2	**1**
Climate Change Adaptation	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological	1	1	1	3	**1**
Climate Change Adaptation	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	1	1	1	3	**1**

Table A3: Management Objective Score

Rank	Option	Description	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	O11	O12	O13	O14	O15	Management Objective Score
			To encourage economically viable and environmentally sustainable land use practices in the catchment	To ensure strategic planning instruments and programs are consistent with and where applicable, directly address the aims of the CZMP	To ensure efficient and effective management of the estuary through appropriate governance, funding and monitoring	To increase knowledge of the impact of existing practices on estuary values and facilitate continuous improvement	To reduce pollutant loads to the estuary	To protect and enhance the riparian zone	To minimise the frequency and severity of environmental events such as fish kills	To optimise flood mitigation works and flow control structures to improve estuarine water quality	To minimise constraints to estuary adaptation to climate change	To protect and enhance the biodiversity values of the estuary	To provide for increased use of the estuary whilst minimising environmental impact and conflict between users	To protect the cultural heritage values of the estuary	To protect and enhance visual amenity/ aesthetic appeal of the estuary	To enhance sustainable commercial return from industries relying on the estuary and the floodplain	To minimise risk to the health and safety of users of the estuary	
2	1	Review estuary governance and administration	1.0	1.0	1.0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	**9**
24	2	EcoHealth monitoring program			1.0	1.0			0.5	0.5							0.5	**3.5**
20	3	Develop catchment/water quality modelling tool to support decision making	0.5				0.5		0.5	0.5	0.5				0.5	0.5	0.5	**4**
17	4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage					1.0		1.0	1.0	0.5	0.5	0.5			0.5		**5**
17	5	Identify and prioritise levees for redesign and/or remodelling					1.0	0.5	1.0	1.0	0.5	0.5	0.5					**5**
14	6	Review floodgate management protocols		1.0			1.0		1.0	1.0	0.5	0.5				0.5		**5.5**
31	7	Cost Benefit Analysis of backswamp farming activities	0.5				0.5		0.5	0.5		0.5				0.5		**3**
31	8	Scientific trials to investigate strategies for retention of water on backswamp areas	0.5				0.5		0.5	1.0						0.5		**3**
7	9	Changes in pasture and harvest management including changes to inundation tolerant pasture species	1.0				1.0	1.0	1.0		0.5	0.5	0.5		0.5	0.5		**6.5**
1	10	Retirement/buy back backswamp areas and return to wetlands	1.0	0.5	0.5		1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	0.5	0.5		**10**
4	11	Work with backswamp property owners to identify alternative management strategies	1.0	0.5	0.5		1.0	1.0	1.0	0.5	0.5	1.0	1.0	1.0	0.5	-1.0		**8.5**
14	12	Farm management planning for priority properties	1.0	0.5	0.5		0.5	0.5	0.5		0.5	0.5			0.5	0.5		**5.5**
7	13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	1.0		0.5	0.5	0.5	1.0	0.5		0.5	0.5			0.5	1.0		**6.5**
11	14	Identify high impact farming activities and investigate alternatives	1.0				1.0	1.0		0.5	0.5	1.0	0.5	0.5				**6**
20	15	Review boat passage areas impacted by erosion					0.5	1.0				0.5	1.0	0.5	0.5			**4**
20	16	Stormwater education		0.5	0.5		0.5	0.5	0.5	0.5	0.5	0.5						**4**
36	17	WSUD for new developments	0.5	0.5			0.5					0.5			0.5			**2.5**
24	18	Retrofit GPTs and other stormwater improvement devices					1.0	0.5				0.5	0.5	0.5			0.5	**3.5**
7	19	Upgrade / augment STPs and other sewerage infrastructure where required					1.0		1.0			1.0	0.5	0.5	1.0	0.5	1.0	**6.5**
31	20	Wastewater Reuse	0.5				0.5					0.5	0.5		0.5		0.5	**3**
39	21	Review water sharing plans regarding groundwater extraction and ASS effects		0.5					0.5			0.5				0.5		**2**
6	22	Riparian buffer zone establishment (planning)	0.5	1.0			1.0	1.0	0.5		0.5	1.0		0.5	0.5	0.5		**7**
2	23	Identify priority riparian areas and rehabilitate	1.0				1.0	1.0	0.5	0.5	1.0	1.0	0.5	1.0	1.0	0.5		**9**
24	24	Aquatic weed management						0.5	0.5			1.0	0.5	0.5	0.5			**3.5**
5	25	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	0.5				1.0	1.0	0.5	0.5	1.0	1.0		0.5	1.0	0.5		**7.5**
20	26	Zoning to prevent access to sensitive estuarine vegetation areas		1.0				0.5			0.5	1.0		0.5		0.5		**4**
31	27	Estuarine vegetation signage / education to protect sensitive areas	0.5	0.5				0.5				0.5		0.5	0.5			**3**
24	28	Implement Recreational Boating Study actions					0.5	0.5					1.0		0.5	0.5	0.5	**3.5**
24	29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public			0.5	1.0						0.5	0.5			1.0		**3.5**
39	30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures				1.0										1.0		**2**
14	31	Further research into sources of water quality issues in North Creek	0.5		0.5	1.0	0.5		0.5	0.5		0.5			0.5	0.5	0.5	**5.5**
31	32	Investigate usage conflicts and need for management		0.5									1.0		0.5	0.5	0.5	**3**
11	33	Develop strategic plan for estuary usage		1.0	1.0	0.5		0.5					1.0		1.0	0.5	0.5	**6**
19	34	Review of waterfront structures and licencing		0.5				1.0					1.0		0.5	0.5	1.0	**4.5**
36	35	Identification and recording of cultural sites available to council planners	0.5	0.5	0.5									1.0				**2.5**
36	36	Cultural site management plans	0.5	0.5	0.5									1.0				**2.5**
7	37	Estuary-wide community education and consultation program	1.0	0.5	0.5	0.5	0.5	0.5	0.5				0.5	0.5	0.5	0.5	0.5	**6.5**
39	38	Cost benefit analysis of dredging operations in lower estuary											1.0			0.5	0.5	**2**
11	39	Assessment and mapping of tidal inundation extent including potential sea level rise	1.0	1.0	0.5	1.0		1.0			1.0					0.5		**6**
24	40	Ongoing on-site sewerage management inspections and improvements	0.5	0.5			1.0					0.5		0.5			0.5	**3.5**
24	41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	0.5	0.5	0.5	1.0					1.0							**3.5**
Priority of Objective (out of 5)			*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	*1*	

Achievement of Objectives: Directly achieves objective (1), Indirectly or partly achieves objective (0.5), Indirectly or partly conflicts (-0.5), Conflicts with the objective (-1.0), does not achieve objective (0)

Table A4: Benefit and Cost Scores

					Likelihood of Achieving Positive Outcomes			Expected Support			
Benefit Rank	**Cost Rank**	**Option**	**Short Label**	**Description**	**Economic**	**Social**	**Ecological**	**Community**	**Agencies**	**Benefit Score**	**Cost Score**
1	11	1	1 Review governance	Review estuary governance and administration	2	2	2	2	2	**10**	**2**
16	2	2	2 EcoHealth	EcoHealth monitoring program	0	1	2	2	2	**7**	**4**
16	11	3	3 DSS	Develop catchment/water quality modelling tool to support decision making	1	1	2	1	2	**7**	**2**
16	2	4	4 Drains	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage	0	1	2	2	2	**7**	**4**
27	5	5	5 Levees	Identify and prioritise levees for redesign and/or remodelling	0	1	2	1	2	**6**	**3**
6	11	6	6 Floodgates	Review floodgate management protocols	0	2	2	2	2	**8**	**2**
4	11	7	7 CBA Bswamp	Cost Benefit Analysis of backswamp farming activities	2	1	2	2	2	**9**	**2**
16	11	8	8 Trial Bswamp	Scientific trials to investigate strategies for retention of water on backswamp areas	1	1	2	1	2	**7**	**2**
16	5	9	9 Pasture	Changes in pasture and harvest management including changes to inundation tolerant pasture species	0	0	3	2	2	**7**	**3**
16	1	10	10 Buy Bswamp	Retirement/buy back backswamp areas and return to wetlands	1	0	3	1	2	**7**	**5**
6	5	11	11 Conv Bswamp	Work with backswamp property owners to identify alternative management strategies	1	0	3	2	2	**8**	**3**
1	5	12	12 FMP	Farm management planning for priority properties	2	2	2	2	2	**10**	**3**
1	11	13	13 Farm BPM	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	2	2	2	2	2	**10**	**2**
34	11	14	14 ID Farm impacts	Identify high impact farming activities and investigate alternatives	0	1	3	0	1	**5**	**2**
16	11	15	15 Boat erosion	Review boat passage areas impacted by erosion	0	1	2	2	2	**7**	**2**
6	29	16	16 SW education	Stormwater education	0	2	2	2	2	**8**	**1**
16	29	17	17 WSUD	WSUD for new developments	0	1	2	2	2	**7**	**1**
6	29	18	18 GPT	Retrofit GPTs and other stormwater improvement devices	0	2	2	2	2	**8**	**1**
6	29	19	19 STP upgrade	Upgrade / augment STPs and other sewerage infrastructure where required	0	2	1	3	2	**8**	**1**
39	29	20	20 WW Reuse	Wastewater Reuse	0	0	1	1	1	**3**	**1**
41	29	21	21 WSP	Review water sharing plans regarding groundwater extraction and ASS effects	0	0	1	0	0	**1**	**1**
27	11	22	22 Riparian plan	Riparian buffer zone establishment (planning)	0	0	2	2	2	**6**	**2**
27	2	23	23 Riparian rehab	Identify priority riparian areas and rehabilitate	0	0	2	2	2	**6**	**4**
27	5	24	24 Aquatic weeds	Aquatic weed management	0	0	2	2	2	**6**	**3**
16	5	25	25 Floodplain cons	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	0	1	2	2	2	**7**	**3**
36	29	26	26 Veg protection	Zoning to prevent access to sensitive estuarine vegetation areas	0	0	2	1	1	**4**	**1**
36	29	27	27 Veg sign	Estuarine vegetation signage / education to protect sensitive areas	0	1	1	1	1	**4**	**1**
6	29	28	28 Rec Boat Study	Implement Recreational Boating Study actions	2	1	1	2	2	**8**	**1**
39	29	29	29 Fish educ	Ensure key research findings in the fishing and aquaculture sector are communicated to the public	0	1	0	1	1	**3**	**1**
27	11	30	30 Oyster	Identify and manage contamination sources in the estuary to minimise oyster harvest closures	2	1	0	1	2	**6**	**2**
4	11	31	31 WQ studies	Further research into sources of water quality issues in North Creek	1	2	2	2	2	**9**	**2**
6	29	32	32 Usage conf	Investigate usage conflicts and need for management	1	2	1	2	2	**8**	**1**
6	11	33	33 Boat facility	Develop strategic plan for estuary usage	1	2	1	2	2	**8**	**2**
36	11	34	34 Wfront	Review of waterfront structures and licencing	0	1	1	1	1	**4**	**2**
34	29	35	35 Cultural reg	Identification and recording of cultural sites available to council planners	0	2	1	1	1	**5**	**1**
6	11	36	36 Cultural SMP	Cultural site management plans	0	3	1	2	2	**8**	**2**
6	11	37	37 Educ&Cons	Estuary-wide community education and consultation program	1	2	1	2	2	**8**	**2**
27	11	38	38 CBA dredge	Cost benefit analysis of dredging operations in lower estuary	0	1	1	2	2	**6**	**2**
16	11	39	39 Tidal Inundation	Assessment and mapping of tidal inundation extent including potential sea level rise	0	2	1	2	2	**7**	**2**
16	29	40	40 OSSM	Ongoing on-site sewerage management inspections and improvements	0	2	1	2	2	**7**	**1**
27	11	41	41 SLR Plan	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	1	1	1	1	2	**6**	**2**
Weighting					*1*	*1*	*1*	*1*	*1*		

BENEFIT SCORING:

0 = not likely to achieve the outcome / not likely to be supported

↓

3 = is highly likely to achieve the outcome / is highly likely to be supported

COST SCORING:

1 =	$0	to $10,000
2 =	$10,000	to $100,000
3 =	$100,000	to $1,000,000
4 =	$1,000,000	to $10,000,000
5 =	> $10,000,000	

Table A5: Overall Options Score

Rank	Option	Description	Initial Score			
			Management Objective Score	Benefit Score	Cost Score	Option Benefit Score
2	1	Review estuary governance and administration	9.0	10	2	**45.00**
38	2	EcoHealth monitoring program	3.5	7	4	**6.13**
22	3	Develop catchment/water quality modelling tool to support decision making	4.0	7	2	**14.00**
36	4	Identify and prioritise drainage for infilling of redundant drains and reshaping of other drainage	5.0	7	4	**8.75**
32	5	Identify and prioritise levees for redesign and/or remodelling	5.0	6	3	**10.00**
13	6	Review floodgate management protocols	5.5	8	2	**22.00**
25	7	Cost Benefit Analysis of backswamp farming activities	3.0	9	2	**13.50**
29	8	Scientific trials to investigate strategies for retention of water on backswamp areas	3.0	7	2	**10.50**
20	9	Changes in pasture and harvest management including changes to inundation tolerant pasture species	6.5	7	3	**15.17**
22	10	Retirement/buy back backswamp areas and return to wetlands	10.0	7	5	**14.00**
12	11	Work with backswamp property owners to identify alternative management strategies	8.5	8	3	**22.67**
16	12	Farm management planning for priority properties	5.5	10	3	**18.33**
3	13	Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	6.5	10	2	**32.50**
21	14	Identify high impact farming activities and investigate alternatives	6.0	5	2	**15.00**
22	15	Review boat passage areas impacted by erosion	4.0	7	2	**14.00**
4	16	Stormwater education	4.0	8	1	**32.00**
17	17	WSUD for new developments	2.5	7	1	**17.50**
5	18	Retrofit GPTs and other stormwater improvement devices	3.5	8	1	**28.00**
1	19	Upgrade / augment STPs and other sewerage infrastructure where required	6.5	8	1	**52.00**
34	20	Wastewater Reuse	3.0	3	1	**9.00**
41	21	Review water sharing plans regarding groundwater extraction and ASS effects	2.0	1	1	**2.00**
14	22	Riparian buffer zone establishment (planning)	7.0	6	2	**21.00**
25	23	Identify priority riparian areas and rehabilitate	9.0	6	4	**13.50**
37	24	Aquatic weed management	3.5	6	3	**7.00**
17	25	Retain, rehabilitate and conserve existing native floodplain vegetation and wetlands	7.5	7	3	**17.50**
19	26	Zoning to prevent access to sensitive estuarine vegetation areas	4.0	4	1	**16.00**
28	27	Estuarine vegetation signage / education to protect sensitive areas	3.0	4	1	**12.00**
5	28	Implement Recreational Boating Study actions	3.5	8	1	**28.00**
29	29	Ensure key research findings in the fishing and aquaculture sector are communicated to the public	3.5	3	1	**10.50**
39	30	Identify and manage contamination sources in the estuary to minimise oyster harvest closures	2.0	6	2	**6.00**
8	31	Further research into sources of water quality issues in North Creek	5.5	9	2	**24.75**
10	32	Investigate usage conflicts and need for management	3.0	8	1	**24.00**
10	33	Develop strategic plan for estuary usage	6.0	8	2	**24.00**
34	34	Review of waterfront structures and licencing	4.5	4	2	**9.00**
27	35	Identification and recording of cultural sites available to council planners	2.5	5	1	**12.50**
32	36	Cultural site management plans	2.5	8	2	**10.00**
7	37	Estuary-wide community education and consultation program	6.5	8	2	**26.00**
39	38	Cost benefit analysis of dredging operations in lower estuary	2.0	6	2	**6.00**
14	39	Assessment and mapping of tidal inundation extent including potential sea level rise	6.0	7	2	**21.00**
9	40	Ongoing on-site sewerage management inspections and improvements	3.5	7	1	**24.50**
29	41	Planning for sea level rise and climate change impacts incorporating Government policy and guidelines, current research and best-practice management	3.5	6	2	**10.50**

Table A6: Issues Score

		Issues	Issue Score	1 Review estuary governance and administration	2 EcoHealth monitoring program	3 Develop catchment/water quality modelling tool to support decision making	4 Identify, prioritise and infill/reshape redundant drains	5 Identify, prioritise and redesign/remodel levees	6 Review floodgate management protocols	7 Cost Benefit Analysis of backswamp farming activities	8 Scientific trials to investigate strategies for retention of water on backswamp areas	9 Changes in pasture and harvest management including changes to inundation tolerant species	10 Retirement/buy back backswamp areas and return to wetlands	11 Work with backswamp property owners to identify alternative management strategies	12 Farm management planning for priority properties	13 Liaise with agriculture industry bodies to improve education and ensure estuary friendly practices are incorporated into industry guidelines	14 Identify high impact farming activities and investigate alternatives	15 Review boat passage areas impacted by erosion	16 Stormwater education	17 WSUD for new developments	18 GPTs and other stormwater improvement devices	19 Upgrade / augment STPs where required	20 Wastewater Reuse	21 Review water sharing plans regarding groundwater extraction and ASS effects	22 Riparian buffer zone establishment (planning)	23 Identify priority riparian areas and rehabilitate	24 Aquatic weed management	25 Retain, rehabilitate and conserve existing native floodplain vegetation	26 Zoning to prevent access to sensitive estuarine veg areas	27 Estuarine vegetation signage / education to protect sensitive areas	28 Implement Recreational Boating Study actions	29 Ensure key research findings in the fishing and aquaculture sector are communicated to the public	30 Identify and manage contamination sources in the estuary to minimise oyster harvest closures	31 Further research into sources of water quality issues in North Creek	32 Investigate usage conflicts and need for management	33 Develop strategic plan for estuary usage	34 Review of waterfront structures and licencing	35 Identify and registration of cultural sites available to council planners	36 Cultural Site management plans	37 Estuary-wide community education and consultation program	38 Cost benefit analysis of dredging operations in lower estuary	39 Assessment and mapping of tidal inundation extent including potential sea level rise	40 Ongoing on-site sewerage management inspections and improvements	41 Planning for sea level rise and climate change impacts incorporating current research and best-practice management
1. Estuary Management and Governance	I1	Lack of protection to estuaries through existing planning instruments.	Pre-requiste	1												1								1				1	1										1	1	1				1		1
	I2	Lack of good governance model for integrated decision making and coordination	Pre-requiste	1	1	1																															1									
	I3	Current environmental monitoring (e.g. water quality) does not allow for assessment of overall ecosystem health, relative impacts of sources or changes associated with management efforts	Pre-requiste	1	1	1																																								
	I4	Lack of clear delineation of administrative and legislative obligations between the parties responsible for estuary management	Pre-requiste	1		1																													1											1
2. Bank Erosion and Sedimentation	I5	Absence or poor condition of riparian vegetation increases bank instability and erosion.	22												1	1	1	1						1	1																	1				
	I6	Unrestricted stock access causes vegetation damage and bank erosion.	13												1	1	1							1	1																	1				
	I7	Lack of incentive for landholders to address bank erosion	15	1											1	1	1							1	1																	1				
	I8	Illegal waterfront access to estuary causes damage to vegetation and bank destabilisation and limit community access	8																					1	1					1						1	1				1				
	I9	Boat wash from power boats has led to riverbank destabilisation and substantial bank erosion, resulting in increased sediment loads to the estuary	9															1						1	1				1							1					1				
3. Water Quality and Fish Kills	I10	Acid water generation and runoff impacts estuarine ecology and contributes to fish kill events and chronic acid impacts (e.g. Red Spot Disease in fish)	20		1	1	1		1	1	1	1	1	1	1	1	1						1			1	1																	
	I11	Blackwater events following flooding have been identified as the major cause of recent fish kills in the mid-lower estuary	20		1	1	1	1	1	1	1	1	1	1	1	1	1									1	1																	
	I12	Agricultural activities including land clearing, use of fertilisers and pesticides, unrestricted stock access to banks, cultivation of steep slopes and high degree of soil disturbance have led to increased sediment, nutrient and contaminant loads to the estuary	25		1	1									1	1	1							1	1		1							1						1				
	I13	Stormwater runoff from some urban areas increases contaminants, litter, nutrients and sediment loads to the estuary	7		1	1													1	1	1				1	1									1						1				
	I14	STP discharges are increasing the load of nutrients and other contaminants to the estuary but the magnitude of impacts is unknown	10		1	1																1	1												1						1				
	I15	Many on-site sewage management systems in the catchment are not registered and condition and impact of on-site sewage management systems on water quality in the catchment is unknown.	7		1	1																													1						1		1	1	
	I16	Poor water quality episodes (particularly nutrients and faecal coliforms) occur in the lower estuary but sources of pollutants are currently unclear	12		1	1													1	1	1	1	1				1								1						1		1	1	
	I17	Lack or poor condition of riparian vegetation reduces the "filtering" of overland runoff and pollutants before reaching the estuary	20		1	1									1	1	1							1	1															1				
	I18	Floodgates can affect tidal flushing, reduce aquatic habitat, interrupt fish passage, alter water chemistry and degrade floodplain soils	21		1	1			1						1												1														1				
	I19	Floodplain drainage provides a conduit for pollutants, blackwater or acid runoff to the estuary especially in the post-peak flood period, and have been identified as a factor in severity of fish kills.	19		1	1	1	1	1	1	1	1	1	1	1												1																	
	I20	Future land use changes pose further threats to estuary health (e.g. further land development, Pacific Highway upgrades)	10		1	1																					1	1													1				
4. Impacts on Native Flora and Fauna	I21	Lack or poor condition of riparian vegetation compromises habitat connectivity and value	9												1	1	1							1	1	1		1	1												1				
	I22	Low ecological value of floodplain habitats results from widespread clearing, fragmentation and weed encroachment	12							1	1	1	1	1	1	1	1									1	1	1												1				
	I23	Damage to seagrass beds and other sensitive estuarine vegetation caused by boat damage, recreational users and unlicensed access points to estuary	9		1																							1	1	1						1	1			1				
5. Fishing and Aquaculture	I24	Poor understanding of recreational and commercial fishing impacts and perceived decline of fish stocks	7		1																										1				1					1				
	I25	QX disease is present in the estuary and has been attributed to large-scale oyster mortality in commercial operations. There is a general lack of knowledge of the triggers of QX and how it may be controlled	7		1																										1	1												
	I26	Poor water quality (particularly faecal coliforms) in oyster culture areas results in extended oyster harvest closure periods and loss of productivity	7		1														1		1	1									1	1	1							1			1	
6. Estuary Users and Conflicts	I27	Community concern about potential conflicts between different estuary uses such as swimming, boating and water skiing	4																											1				1	1	1			1				
	I28	Current boating infrastructure in the lower estuary is inadequate to provide the expected level of service for local and visiting boats	6																											1				1	1	1			1				
	I29	Illegal waterfront structures allow access to estuary posing risks to public safety	4																											1				1	1	1			1				
	I30	Siltation is affecting navigation and/or safety in the lower river	6																											1					1				1	1			
	I31	Lack of provision of appropriate public access to foreshore	14																									1	1	1				1	1	1			1				
7. Social and Cultural	I32	Protection of Aboriginal cultural heritage sites around the estuary from disturbance or destruction by river works and development	6																																		1	1	1				
8. Climate Change	I33	Predicted sea level rise may result in impacts associated with shoreline recession, implications for draining and flooding, damage to infrastructure, habitat modification including inundation of low lying ecosystems, landward migration of ecological communities and bank erosion	12		1	1	1	1	1	1	1	1	1	1	1	1	1							1	1		1											1	1		1		1
	I34	Possible increase in frequency and intensity of storm events due to climate change and altered flooding patterns, exacerbating erosion, bank stability, habitat modification and water quality issues	12		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1				1	1		1											1		1		1
		Total Issues Scores		**115**	**275**	**270**	**83**	**63**	**104**	**95**	**95**	**95**	**95**	**95**	**220**	**205**	**180**	**43**	**38**	**31**	**38**	**29**	**22**	**45**	**152**	**152**	**73**	**176**	**79**	**41**	**51**	**21**	**14**	**93**	**28**	**92**	**70**	**31**	**43**	**287**	**6**	**68**	**26**	**74**

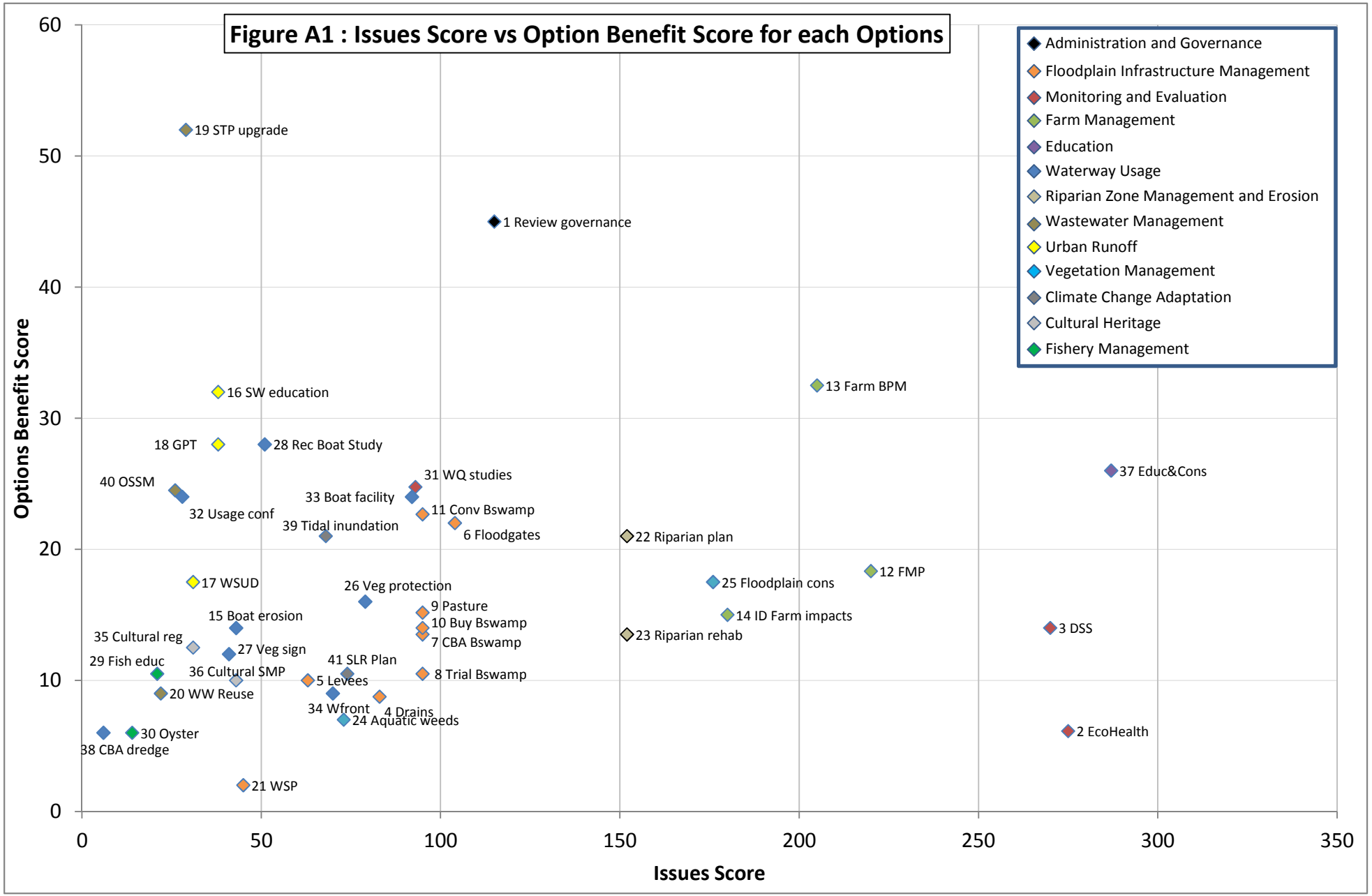
Figure A1 : Issues Score vs Option Benefit Score for each Options
Options Benefit Score
Issues Score
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
Administration and Governance
Floodplain Infrastructure Management
Monitoring and Evaluation
Farm Management
Education
Waterway Usage
Riparian Zone Management and Erosion
Wastewater Management
Urban Runoff
Vegetation Management
Climate Change Adaptation
Cultural Heritage
Fishery Management
19 STP upgrade
1 Review governance
16 SW education
13 Farm BPM
18 GPT
28 Rec Boat Study
37 Educ&Cons
40 OSSM
31 WQ studies
33 Boat facility
32 Usage conf
11 Conv Bswamp
39 Tidal inundation
6 Floodgates
22 Riparian plan
12 FMP
17 WSUD
26 Veg protection
25 Floodplain cons
9 Pasture
15 Boat erosion
10 Buy Bswamp
14 ID Farm impacts
3 DSS
35 Cultural reg
7 CBA Bswamp
23 Riparian rehab
27 Veg sign
29 Fish educ
41 SLR Plan
36 Cultural SMP
8 Trial Bswamp
5 Levees
20 WW Reuse
34 Wfront
4 Drains
24 Aquatic weeds
30 Oyster
2 EcoHealth
38 CBA dredge
21 WSP

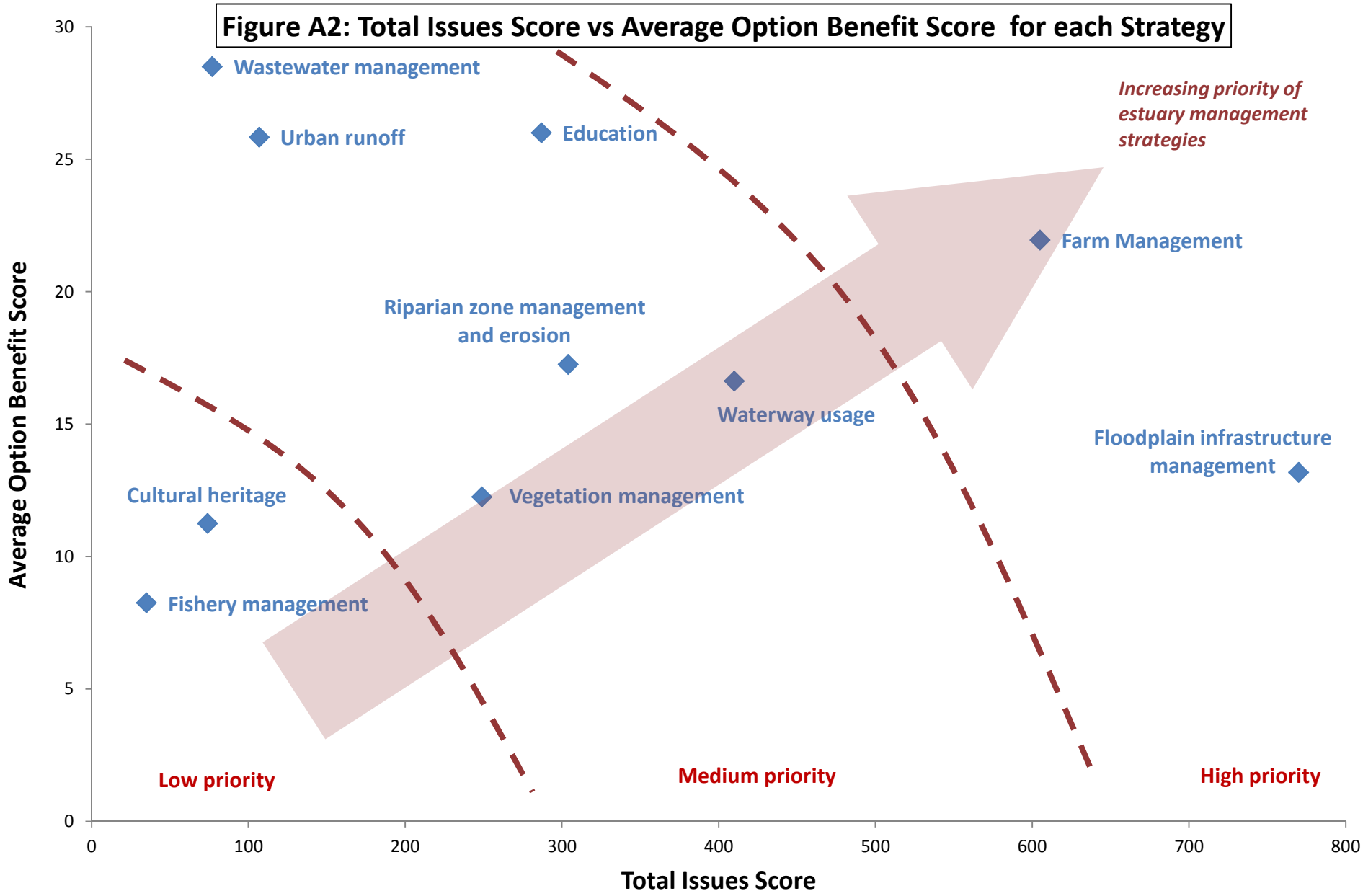
Figure A2: Total Issues Score vs Average Option Benefit Score for each Strategy
Wastewater management
Urban runoff
Education
Increasing priority of estuary management strategies
Farm Management
Riparian zone management and erosion
Waterway usage
Floodplain infrastructure management
Cultural heritage
Vegetation management
Fishery management
Low priority
Medium priority
High priority
Average Option Benefit Score
Total Issues Score
0
5
10
15
20
25
30
0
100
200
300
400
500
600
700
800